Final Report

Minimizing cold air flow underneath a chicken coop trailer

Client/Project Partner: Blake Lanphier
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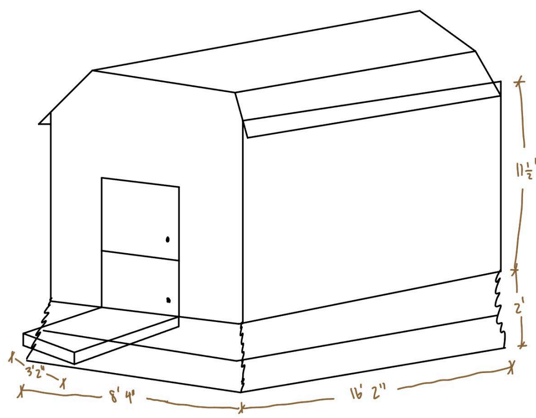
Executive Summary

The Historic Wagner Farm houses over 120 chickens in a mobile chicken coop trailer. It has a grated floor that allows cold air to enter underneath in winter yet is necessary for chicken droppings to fall through. We designed a trailer skirt that minimizes cold airflow by creating a barrier around the base of the trailer.

The CluckCurtain presents an insulated structure that remains attached to the lower part of the coop throughout the year. Each section of the curtain consists of ripstop fabric, two heavy metal pipes, wool insulation, heavy duty zippers, grommets, screws, and hooks. The hooks and zippers allow the CluckCurtain to be folded up over the summer and when transporting the coop.



- Durable: Based on research on chicken care, trailer skirts and context/environment of use, we have chosen wool insulation and ripstop fabric with metal pipes in each section of the design– this is durable against chickens and harsh weather conditions: rain, wind, snow, and hail. The pipes are hollow to be more structurally sound and heavy to keep the fabric weighed down in strong wind.
- Insulating: Wool insulation is waterproof and helps the trailer retain heat, which is a key requirement for the chickens' environment. The foldable design provides increased ventilation for the chickens as needed in summer.
- Convenient to store: The heavy duty zippers combining the sections are easy to unzip when the design is folded. The product is also easy for the Wagner Farm staff to use regularly, requiring only up to two people to store safely.

Next steps include building the full sized product, as the current prototype models only one section of the skirt. Limitations/risks involving the use of the CluckCurtain are that the fabric may be damaged by the chickens and the skirt may be caught on the wheel or hitch of the trailer while being moved.

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Introduction

We are a group of first-year undergraduate engineering students working to solve a problem for Mr. Blake Lanphier of the Historic Wagner Farm, as a part of our Design Thinking and Communication course at Northwestern University. The Historic Wagner Farm, located in Glenview, Illinois, USA, is a functional farm which centers around community involvement and agricultural education. The farm raises animals including horses, cows, pigs, goats, and chickens. Our project involves designing a solution which minimizes the influx of cold air entering the coop up through the grated floor (Fig. 1) (Appendix A: Project Partner Interview Summary). In the winter, these cold drafts decrease the interior temperature, increasing the chance of the water system freezing. Additionally, these drafts can stress the chickens and increase their chance of frostbite (Appendix B: Secondary Research Summary).

While the grated metal floor provides some benefits for the farm and their staff, the winter chill greatly decreases the floor's utility. In summer, this type of flooring allows the chicken droppings to fall through the bottom of the coop and fertilize the ground beneath, especially when the coop is moved to various locations around the farm biweekly. However, when the temperature drops below freezing, the chicken defecation freezes to the floor instead of falling through, which can cause health problems for the chickens as well as a general mess. The frozen defecation further decreases the ability of the floor to allow the dropping to fall through, compounding the issue. During the summer, the extra ventilation is desired since it decreases humidity and the buildup of ammonia gas from the chicken defecation (Appendix C: Project Definition).

Fig. 1. Wagner Farm's Older Chicken Coop

To reduce the cold air entering, the Wagner Farm staff stack hay bales, two bales tall, around the perimeter of the coop. This prevents the air from flowing in; however, it also makes it much more difficult to move the coop, since the hay bales must first be moved before moving the coop. They previously tried using a plywood skirt around the trailer before switching to the hay bales. It sat about two inches off the ground and, while it succeeded in blocking out the wind above the two-inch gap, was not convenient to remove when the trailer was moved to a new location, and was prone to fracturing upon impact with the ground while it was being moved. Additionally, there is a small section of rubber on the front of the coop which functions as part of a skirt (Fig. 2). However, by itself it was too thin and did not provide adequate insulation for the coop.

Fig. 2. Current Rubber Panel Skirt

We designed the CluckCurtain, a waterproof fabric skirt which will attach permanently to the coop (Fig. 3). It is weighted to prevent wind from entering from beneath, and the inside is filled with insulation to minimize heat loss. It can also be flipped up to be stored in the summer and to move the trailer. This can be done by folding up the bottom edge to hang on hooks installed right above the top edge.

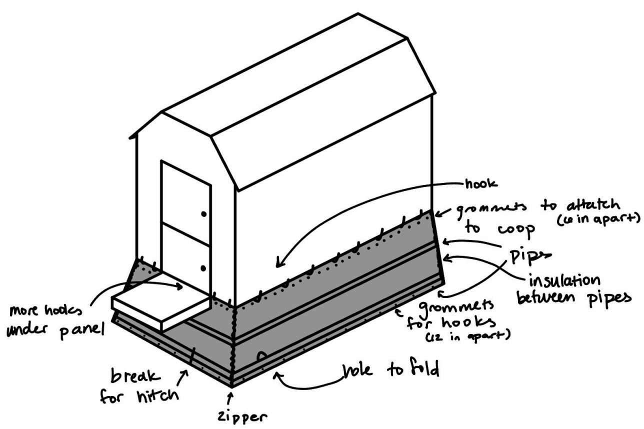

Fig. 3. The CluckCurtain

Users and requirements

Farm staff
Wagner Farm employees, who are farmers, are the primary users of our product. These farmers have been working on Wagner Farm for long periods of time and some helped assist in building the chicken coop itself, so they are familiar with its structure and set up. These staff will be the ones to move the product weekly when transporting the chicken coop to a different location, and are typically under a time constraint and thus need the product to be easy to use.

Chickens
The coop houses approximately 115 Red Star chickens from Murray McMurray Hatchery, also known as ISA Browns. The chickens cannot tolerate extremely low temperatures. The chickens are allowed outside during the day so they can wander and range on their own time, and come inside the coop during the night. During the winter, the chicken coop doors are still left open for the chickens but they tend to prefer to stay indoors

Requirements
The coop that we are working on requires our design fit the **dimensions** of Wagner Farm's existing coops**,** as specified in the project definition (Appendix D: Mockup Testing Summary). There will be one or two staff members working with the coop at a time, so another design requirement is for the design to be ideally **easy to use by one person** who can lift **under 20 lbs**. Similarly, the design must be relatively simple to use with a preferred number of **3-5 steps to store/set up**. Another design requirement is that the design is able to be **stored over the summer** and **durable**, so as to withstand the elements and pecking from the chickens.

The CluckCurtain: Design Concept

The CluckCurtain (Appendix E: Safety Evaluation) is a type of trailer skirt which wraps entirely around the lower edge of the coop to prevent the influx of cold air up through the bottom of the coop (Fig. 4) (Fig. 5). Each side of the coop has several key components: fabric, insulation, pipes, zippers and fasteners. We developed the design as a result of feedback and testing (Appendix F: Design Review Summary).

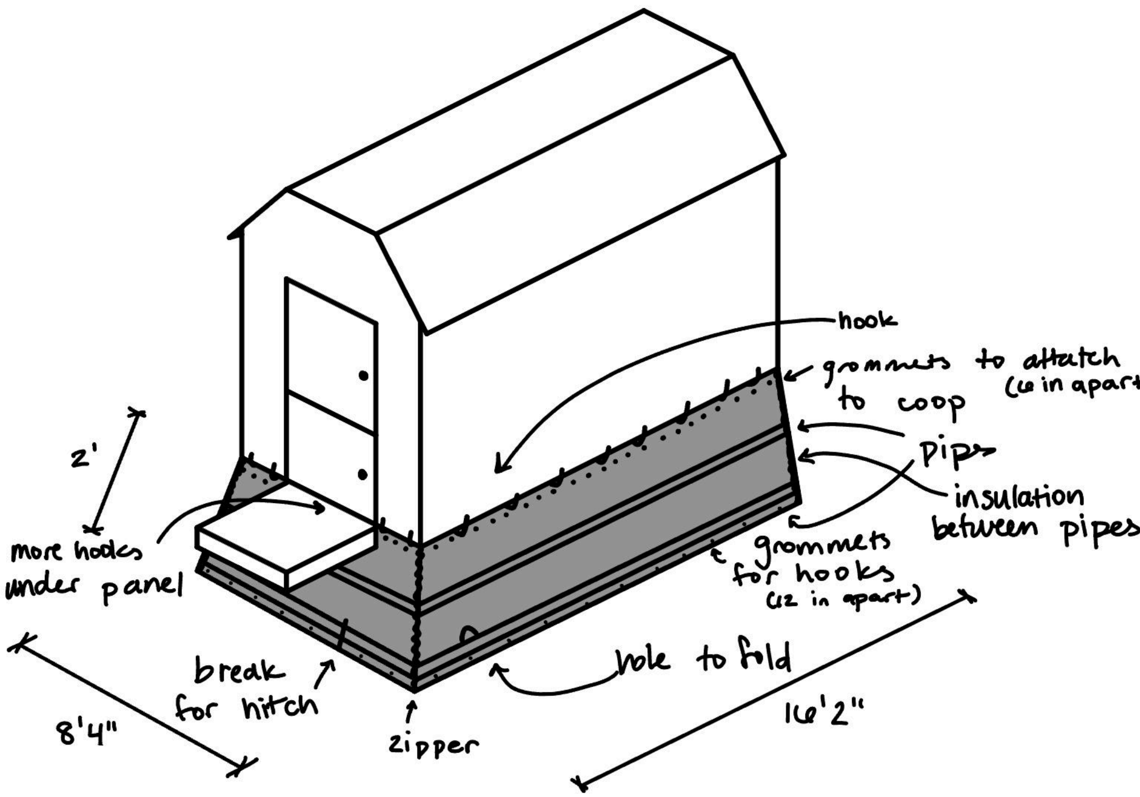

Fig. 4. Trailer Skirt Isometric View

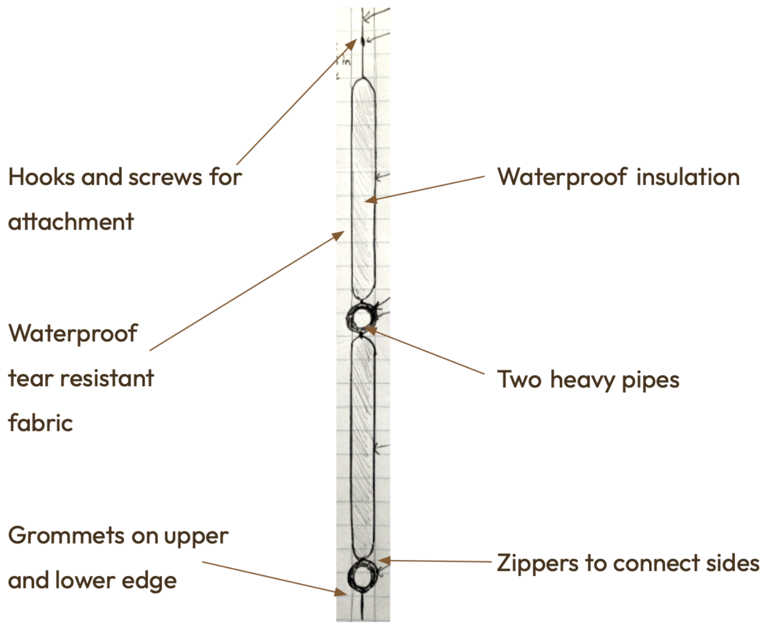

Fig. 5. Trailer Skirt Side Cross Section

Fabric and insulation

The outer layer of CluckCurtain will be Ottertex Waterproof PU Coated Nylon Ripstop, which is weather resistant and durable (Fig. 6). According to Ottertex Fabrics, the suppliers of this fabric, nylon ripstop is commonly used for outdoor purposes such as camping equipment, vehicle covers and outdoor clothing. This makes it effective for the CluckCurtain since it is proven to resist wet and extreme weather conditions. Its reinforced stitching every ⅛" prevents easy tearing in the case of pecking by chickens. Waterproof PU coated fabrics also typically have a tear strength of 50 N warp, indicating that this material is very durable (Appendix C: Project Definition).

The interior of each section is filled with insulation material to allow the coop to retain as much heat as possible. When choosing an appropriate wool insulation, it is important to consider the effects of rain and snow that may be present. As a result, Havelock wool PRO R20 Batt Insulation - 24" OC is recommended because it does not allow easy mold growth and is not toxic to handle, unlike other types of insulation (Appendix H: Instructions for Construction for the CluckCurtain).

To create the main body of the skirt, the outer Ripstop fabric is folded and sewn to create pockets, into which the pipes and insulation are inserted. Adding the insulation will cause the design to not only stop wind, but also to trap heat under the bottom of the coop and keep the chickens warm.

Fig. 6. Insulation and Ripstop Fabric Used for the Skirt

Pipes

Pipes will be located halfway down the length of the design and at the bottom to add weight and stability. The pipes will be hollow in order to maximize radius while maintaining the same weight and to prevent it getting caught under the wheels (see Moving the Coop in the Winter). Hollow pipes are more rigid than solid pipes of the same mass. They will be made of steel to ensure that they weigh enough to hold down the skirt and prevent it from flapping in the wind, which would increase airflow and render the design useless (Appendix D: Mockup Testing Summary). If a less expensive option were needed, PVC pipes could be used as an alternative to metal pipes; however, steel pipes are recommended as they are heavier and stronger.

Fig. 7. Pipes Used for the Skirt Prototype

Zippers

Zippers at the corners of the trailer can be zipped together, which minimizes the cold air entering at the corners of the coop. Having the design be more connected will also minimize movement due to wind, since the sides can no longer move separately. The zippers that are recommended are used for outdoor purposes, so they are adequately weather and wear resistant.

Grommets, Screws, and Hooks

The skirt has grommets (Fig. 8) along its top and bottom edge (Fig. 4) to create durable connection points to the coop.

Fig. 8. Grommets Used for the Skirt

The skirt is attached to the coop by inserting screws through the upper grommets and screwing the skirt to the coop (Fig. 9). This minimizes gaps across the top of the design. The screws should be placed 6'' apart at the top edge, in order to minimize gaping and bending of the fabric and ensure that it is a strong enough connection. A washer can be used so that the screw is wide enough to stop the skirt from falling off of the screws. There will be hooks attached to the trailer above the skirt so that the bottom half can be folded off the ground, as described in the next section.

Fig. 9. Skirt Attachment to the Coop

Movement and Summer Usage

There are two situations when it is desirable to fold up the skirt - in the summer and when moving the coop during the winter (Appendix G: Instructions for Use). During the summer, folding up the skirt allows increased ventilation into the coop and lets the chickens hide in the shade under the coop. During the winter, temporarily folding up the front of the skirt is desirable to avoid the skirt possibly hitting the wheels while moving.

Summer Use

During the summer the skirt will be folded onto hooks on the side of the trailer (Fig. 10). This is possible with one person, but easier and faster with two. First, unzip all of the zippers. Bring the bottom pipe up to the row of hooks and hook each grommet onto the row of hooks. To unfold after summer, unhook the grommets from the hooks, fold the design back down, and zip each corner closed.

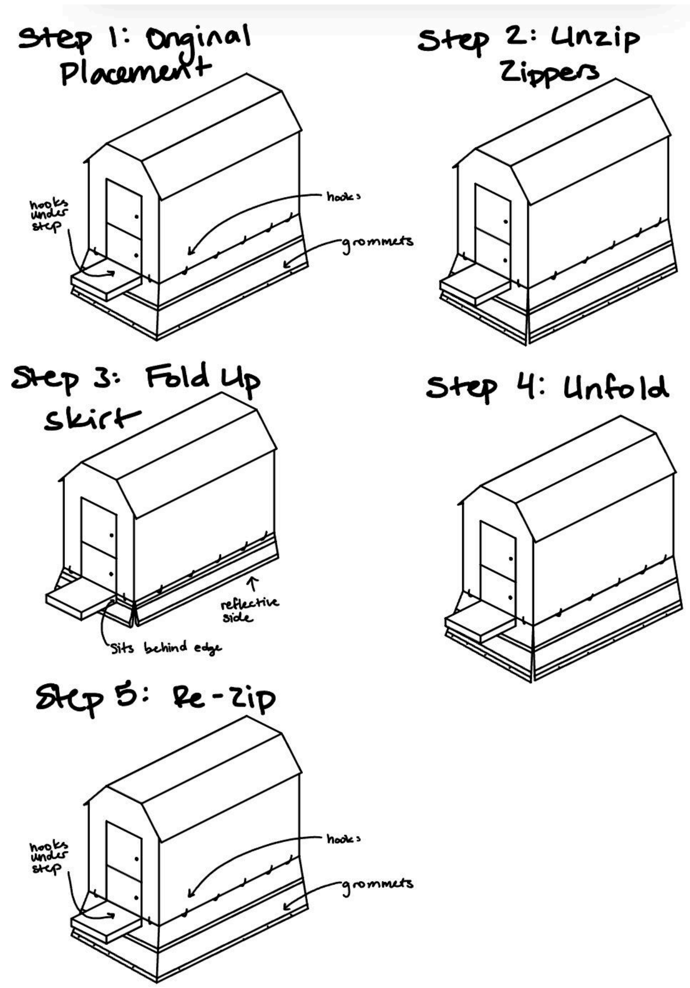

Fig. 10. Storyboard of Summer Storage

Moving the Coop in the Winter

When the coop is moved in the winter, the CluckCurtain is designed so that it can be folded up partially to avoid it getting caught under the wheels (Fig. 11). First, unzip the two front corner zippers halfway. Then, fold the front of the skirt onto a hook, so that it is sitting at a diagonal. Move the coop, then put the skirt back down and re-zip the zippers.

If the skirt is not unzipped and raised when moving, there is a chance that the skirt will become caught under the wheels and rip off of the coop. We expect that this will not happen and that the piped will simply cause it to bounce off; however, this has not yet been tested. If this becomes an issue, we would recommend replacing the pipes with ones of a larger diameter, which would decrease the dangers of this occurring (see Limitations and Next Steps). However, in either case, folding up the skirt to move the design would still be the safest option.

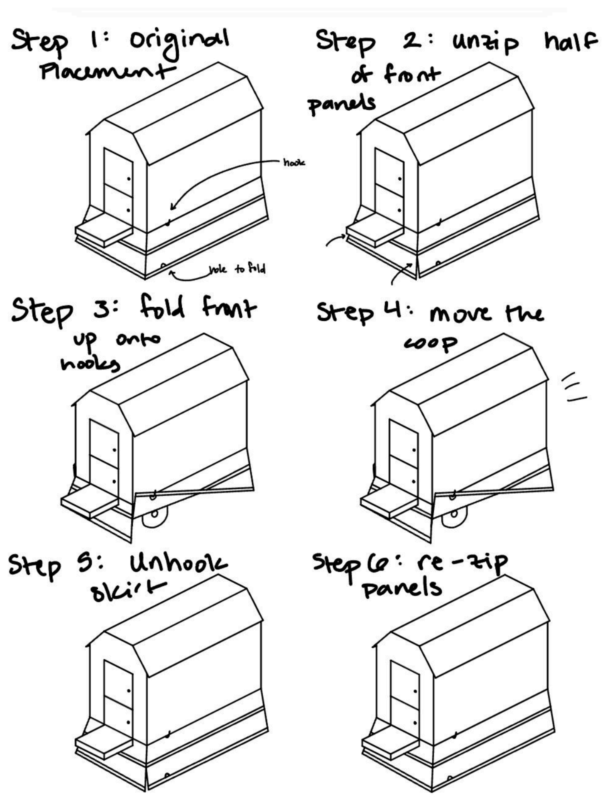

Fig. 11. Storyboard of Moving the Coop with Skirt Attached

Limitations and Next Steps

While mockup testing and background research has informed the elements of the design, the CluckCurtain lacks long term testing on the chicken coop in the winter. This means that there are certain limitations to the current skirt solution. Some limitations such as durability cannot be reliably tested in the short term and others require larger prototypes tested on the coop. The limitations that we have identified came from the testing that we did with our initial prototype at Wagner Farm (Appendix D: Mockup Testing Summary). Instructions for how we built our current prototype as well as the materials and methods used can be found in (Appendix H: Instructions For Construction). For future testing, it is recommended to attach our prototype to a front corner of the coop.

Test the ripstop material for durability
Test the fabric by placing the prototype on the coop for at least one week and assessing if it has been damaged or not. Damage could occur if the chickens peck the fabric or if environmental factors such as rain or snow negatively affect it. We recommend using an alternative fabric if issues occur, such as one made out of a canvas instead of nylon, which will be stiffer, but more durable.

Test the CluckCurtain for Catching on the wheels
Unscrew the wood from the prototype and attach the skirt to the base of the coop. Then, move the coop without unzipping or folding up the front corners of the skirt. If the skirt breaks, we recommend using a larger radius pipe, since this would make the skirt more likely to bounce off of the wheel instead of getting caught under. Further testing would need to be done in order to determine the necessary dimensions of the larger-radius pipe.

Use heavier pipes
Place the prototype onto the coop on a windy day with the panels unzipped and observe if the fabric flaps in the wind. If the skirt blows too much, weigh the CluckCurtain with heavier pipes to decrease its movement or implement stakes to attach the design to the ground.

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Appendix A: Project Partner Interview Summary

Our interview was conducted in person at Historic Wagner Farm on April 8th at 2:30 with Blake Lanphier, the Farm Manager. As a team, we had the opportunity to talk with him and discuss questions that had come up during our secondary research investigation, as well as see the chicken coop and collect measurements and other data. We also discussed the possibility of visiting the Historic Wagner Farm again after ideation and prototyping.

Methodology

To conduct our initial project partner interview, our team traveled to the Historic Wagner Farm and met with Blake Lanphier to discuss the issue and current problems. We observed 115 chickens walking in and around the newer coop, and were able to enter and take measurements of the older, unoccupied one. Blake also discussed with us the problem at hand, as well as how they are currently addressing the issue and how they have dealt with it in the past.

Problem Description/Current Solutions

The problem currently faced by the Historic Wagner Farm staff is the influx of cold air which flows through the bottom of the chicken coop. This is especially a concern in winter, since the flow of cold air can make the coop reach temperatures as low as 27°F. This causes problems both because it is an uncomfortably cold temperature for the chickens, but also because it lowers the temperature of the grated metal flooring, which can cause the chicken manure to freeze to it and consequently build up. There were two coops; a newer one which is currently in use, and an older one that is currently going through some maintenance. The length of the newer one is 18 ft (about two feet longer than the older one).

The current solution to the problem of air flowing in is to stack hay bales, two tall, around the perimeter of the coop. This does prevent the air from flowing in; however, it also makes it much more difficult to move the coop, since the hay bales must first be moved before moving the coop. Ideally, the project partner is hoping to be able to move the coop about once a week in the wintertime, so whatever solution is created should be able to move with the coop itself, or should be easily removable and reattachable.

The client also mentioned that they had previously tried a plywood skirt around the trailer before switching to the hay bales. It sat about two inches off the ground and, while it succeeded in blocking out the wind, was not removed when the trailer was moved to a new location, and was therefore prone to fracturing upon impact with the ground while it was being moved.

Design Constraints & User Considerations

The client specified that he is mostly looking to prioritize animal welfare and placing the chicken coop out in the field for longer periods of time during the year. The chickens used are Red Star chickens from Murray McMurray Hatchery, also known as ISA Browns. He is looking for a solution that can be applied to his chicken coops in particular. This means that we will need to consider the dimensions of the current coop as well as its wooden structure with metal grated floor. We will also need to respect the material constraints of introducing a design that interacts with the chickens. Mr. Lanphier mentioned that choices of softer materials such as styrofoams will be “destroyed” by the chickens very easily because they will peck at it or go underneath it to get under the trailer. Since the coop will need to be moved often, the solution must also accommodate for this—either by storing on the trailer in some way or by being removed during the summer.

Measurements

There are two chicken coops, with the “new” coop being 2 feet longer than the old coop. The “old” coop is pictured in Figure A1. The exterior of the old coop is 16 feet 2 inches long and 8 feet 4 inches wide. The interior is 14 feet long and 7 feet 3 inches wide. The bottom of the old coop is 2 feet off the ground, with the white border being 3.5 inches wide. The bottom of the new coop is 2 feet 2 inches off the ground. The platform for the entrance of the coop is 2 feet by 3 feet 2 inches. The lowest point of this platform is 1 foot 9 inches off the ground. See sketches of the dimensions of the old coop in Figure A1.

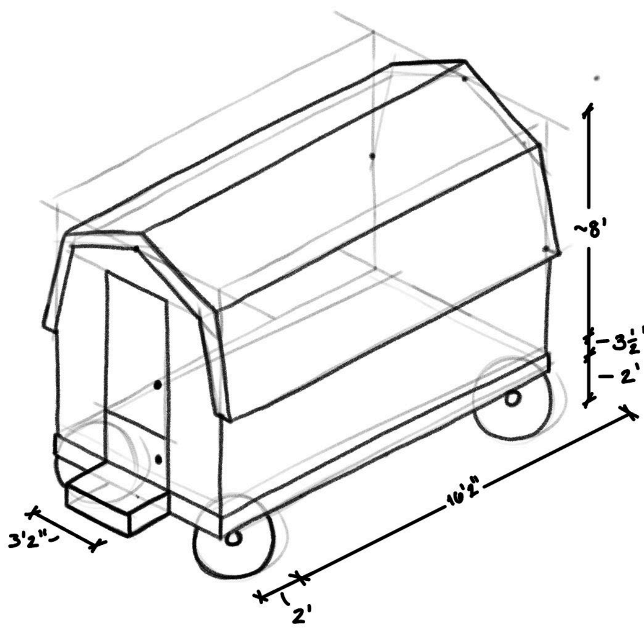

Fig. A1. Sketch of Older Chicken Coop

Fig. A2. Older Chicken Coop

Discussion

From our observations, we believe that it would be most feasible to create a solution that can be fastened onto the current chicken coop structure. Based on the old solutions that the farm has already tried to use, we will evaluate design decisions to make the most effective solution. Some factors we will consider are the materials, dimensions and safety factors related to working with animals. We also aim to create a solution that is easy for the farm staff to use, remove from the coop, and store during the summer months.

Appendix B: Secondary Research Summary

Historic Wagner Farm is a farm located in Glenview, Illinois that raises multiple animals including chickens. They have two mobile chicken coops with grated floors which allows chicken droppings to fall through. The mobility of the coop allows the farm to periodically move the coop and utilize the poop as fertilizer instead of cleaning the floor daily. Additionally, they lack a convenient solution to prevent cold air from entering from underneath the coop that would be as mobile as the coop. This research aims to aid the team in the brainstorming, design, and construction of a functional trailer skirt that would prevent cold air from entering underneath the coop.

Chicken Care & Cold-Weather

There are many chicken breeds that are raised for specific needs (eggs, meat or looks). Medium-large breeds are better at surviving in winter settings [1]. Some popular breeds include:

- Rhode island red (brown eggs, 6.5 pounds, dark red)
- Wyandotte (brown eggs, 6.5 pounds, round shape)
- Ameraucana (different colors, green eggs, long term egg production, can survive all climates)
- Orpington (8 pounds, brown eggs, heavy and good for winter)

Typical chicken diets include grains, fruit, vegetables, insects as chickens are omnivores. Usually, a 6 pound hen will eat 3 pounds of feed per week - this is increased in winter.

Chicken housing and chicken coops are extremely important to control in order to maintain good health for the chickens. Egg-laying chickens need nest boxes (one box for 4-5 hens). Chickens like to roost in high places, so they need somewhere to do this. Insulation (e.g. heat lamp) is needed for winter. Hens need 12-14 hours of light to lay eggs, a light bulb can be sufficient. [1]

In terms of chicken healthcare, water and food must be changed daily. They should be let outside of the coop during the day. Eggs must be picked up twice a day and the coop should be cleaned weekly. Healthy chickens are normally active, alert and talk/sing quietly.

Chicken manure consists of 'feed residue, intestinal bacteria, digestive juices, mineral by-products from metabolic processes, and water'. In fact, 85% of chicken droppings is water. This leads to humidity and consequently odor problems. Solutions for this include cleaning often, having moveable coops, and compostable bedding. The manure is 70% water, which makes manure management important when controlling moisture in your coop. One should routinely pick up manure and remove soiled bedding throughout the winter [2].

Most chickens can maintain their body temperatures when the temperature is between 60 and 75 degrees Fahrenheit, and the average body temperature of a chicken is 106 degrees Fahrenheit. It is estimated that chickens can tolerate up to 40-45°F [3]. Low temperatures in the environment can lead to stress in poultry, and prolonged cold stress can reduce egg production performance and lead to death. One can identify if a chicken is too cold if they are huddling together, holding a foot up to their breast, or puffing their feet [1].

In cold weather, it's crucial to provide supplemental heat for chicken coops when temperatures drop below 35 degrees Fahrenheit, which should be placed at the height of the nest boxes or lower rung of the roost. Thermometers should be placed on the wall at this height as well to keep track of coop temperatures.

Proper ventilation is also essential to prevent moisture build-up and poor air quality due to ammonia, which can be achieved by partially opening south-facing windows, installing roof vents, using burlap to encourage air movement, and opening doors or windows on warmer days [1]. Maintaining a balance between ventilation and insulation is crucial. Sealing the coop too tightly can lead to moisture build-up and thus frostbite as well as ammonia build up, and drafts can stress chickens and make them feel cold, possibly increasing the chance of frostbite [2].

Heavier breeds like Plymouth Rock, Wyandotte, Ameraucana, and Orpington are better suited for cold weather, while smaller breeds which have less feathering, or have large combs and wattles, may need extra care to stay warm, maintain body weight, and stay healthy during the winter [1].

There exist some more strategies for keeping chickens warm in winter:
- Ventilation
- Moisture control
- Frostbite protection (vaseline/oil on exposed skin)
- Flat roosting bar (chickens can cover their feet with feathers)
- Large flocks (huddling)
- Fresh water
- Caged heat lamps/ heating sections for very cold weather

Chicken Coop Flooring Types

Grated Flooring

Chicken coops with wire flooring (pictured below) is a very common type of grated flooring and can be beneficial for many reasons:

Fig. B1. Picture of a Wire Chicken Coop Floor [6]

The wire framing can allow droppings to fall through the flooring, which can minimize cleaning and maintenance of the coop. Additionally, wire can provide ventilation through the bottom of an elevated coop, since it allows air to flow through the bottom. However, this type of flooring can also be problematic since droppings, or the chicken's feet, may get stuck in the wires [5]. Additionally, while this type of coop flooring is very common in warm climates, it tends not to work well in cold weather regions due to the fact that it lets in lots of cold air [6].

Other Flooring Types

Other common types of flooring used in chicken coops include concrete and wood/plywood [5], as well as simply having a dirt floor [6]. Concrete is very durable and easy to clean, and also protects chickens from burrowing predators. However, it can be dangerous to falling chickens since it is so hard, and can be extremely cold in the wintertime, making it unsuitable for cold climates. On the other hand, wood is warmer but can rot or be burrowed into by other animals [5].

In addition, there are various types of materials, including paint, linoleum, vinyl, or rubber mats that can be used as liners on the floor of a coop. Oftentimes, these can mitigate some of the problems experienced by having an exposed wood or concrete floor [6].

Trailer Skirts

Trailer skirts are used in truck trailers to decrease aerodynamic drag by preventing "wind from ducking in under the trailer and running into the trailer bogie" [7]. Effectiveness of the skirt increases as the skirt becomes closer to the ground, but may need to be shorter depending on the terrain. Most trailer skirts are "flat sheet materials—composite, metallic, or both" [7].

Fig. B2. Trailer skirt on an RV [8]

Skirts are bracketed to the underside of the floor structure of the trailer. Some skirts also include a "rubber flexible strip at the bottom to help close the gap between the ground and the bottom edge of the skirt" [7].

In RVs the skirting is used to “trap warmth in and keep cold air out” [8]. While also improving the heat inside, the skirting also prevents the pipes and water from freezing. One example is the EZ Snap, which is installed by snapping onto adhesive studs to the side of the RV and snapping the vinyl skirt onto the trailer.

Context/Environment of Use

Weather conditions in Glenview, IL, during winter often include rain and snow. The coldest temperatures can be around -20°F in winter. This is much below the tolerance of chicken breeds. Specifically for the Historic Wagner Farm, the solution will be used mostly by the farm staff. It may also be used by any people who might visit the farm, who could be community members or people from the greater Chicago area, including children.

Weight and Lifting Standards

While OSHA does not have and standards or statutes relating to how much a worker can lift or carry, they do cite NIOSH, which developed a lifting equation based on a base maximum of 51 pounds, which then adjusts for how “often you are lifting, twisting of your back during lifting, the vertical distance the load is lifted, the distance of the load from your body, the distance you move while lifting the load, and how easy it is to hold onto the load” [9] For the purpose of this project, a weight below 35 pounds would be a good goal.

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Appendix C: Project Definition

Project name: Project Coop Warmer
Client: Historic Wagner Farm/Blake Lanphier/Jon Kuester

Mission statement

Develop a solution that minimizes cold air entering the grated floor of the chicken coop trailer. The design will allow the Historic Wagner Farm staff to move the chicken coop trailer easily and efficiently. The chicken droppings must be able to fertilize the ground without staff intervention.

Project Deliverables

- Final report
- Presentation during our class presentation
- A prototype of our solution that demonstrates its basic functions and could then be manufactured as a final product

Constraints

- Project due date (June 4th)
- Product must preserve the well being of the chickens

Users and Stakeholders

- Blake Lanphier, Jon Kuester, and other Wagner Farm employers
- Chickens
- Visitors to the farm

User Profile

Wagner Farm employees, who are farmers, are the primary users of our product. We primarily interacted with Blake Lanphier, the farm manager. He is a middle aged man who is one of the main farmers interacting with the coop. He has years of experience at the farm and has built the chicken coop, so he is well aware of its functions.

Illustrative User Scenario

The user in the illustrative scenario below is a member of the Wagner Farm staff. She unlocks the wheels of the trailer and moves the chicken coop trailer to a new patch of grass in the field. As she pushes the trailer, the wooden planks attached to the side of the coop/trailer hit the floor and break. The wooden planks that are in place to prevent cool air from flowing into the coop are now no longer usable, and she thus has to implement new wooden side sections.

Table C1: List of Requirements

Needs	Metrics	Units	Ideal Value	Allowable Value
Dimensions	Weight	lb	< 20 Based on personal experience	35
	Max length	ft	16 Measured coop	16
	Max width	ft	10 Measured coop	10
	Max height	in	24 Measured coop	27
	Min height	in	24 Measured coop	23
Durability: Withstand the elements (rain, wind, snow, hail)	Temperature	ºF	-30	-20
	Waterproof Fabric Polyurethane (PU) Coating	N warp (tear strength)	50	25
Materials	Tear resistant fabric with	Type of Fabric	Ripstop	PU Coated Nylon Ripstop
Attachment	Steps needed to unzip and store	Integer	3	5
Fold up for summer	Weight to lift	lb	20	30
	Number of people	Integer	1	2

Appendix D: Mockup Testing Summary

This mockup testing served to evaluate the four initial mockup ideas for designs that minimize the airflow coming in through the floor of the chicken coop. The initial design ideas included (1) fabric with wood and stakes, (2) a single hung “window”, (3) rolling straw, and (4) fabric with stakes. Each of these designs were tested using the methods outlined below, yielding the corresponding results. These tests were conducted at the shop by Alvin, Izzy, Charlotte and Pavi on April 25th at 10am. Tests of mockup designs (1) and (4) were done in person at Wagner Farm on April 29th at 3:30 PM.

Methodology

On Campus Testing

Start Time: 4:00 pm **End Time:** 4:30 pm

The design ideas that were tested on campus include four attached to the same mockup frame (see Fig. D1):

- Fabric with wood
- Single-hung window
- Straw
- Fabric with stakes

Fig. D1. Stand with mockups (one section per side)

Each design was tested first for wind-resistance (Fig. D2), and then for convenience. In order to test for wind resistance, the design was placed in front of a fan and an anemometer was used to measure the velocity of air flowing in front and behind the design. From the difference in these two numbers, we were able to tell how effective the design is. The amount that the design was pushed back was also observed. The convenience of the design was observed by moving or folding the designs up and down on the mockup and measuring the time taken to store it.

Fig. D2. Mockup testing setup with the Fan

For the individual designs, we observed the behavior of its unique features. For instance, with the window-inspired mockup, we also tested the feasibility of the "window" by determining how best to construct it such that it will stay still in both an "open" and a "closed" position. The initial mockup was based on a simple friction fit design. Next, the straw design was tested using a few varieties of weaving techniques for the sections themselves– this was done using paper towels to simulate straw. Lastly, we qualitatively evaluated whether the sections can be easily rolled upwards.

Testing at Wagner Farm

The mockups that were tested at Wagner Farm include:

- Fabric with wood
- Fabric with stakes
- Fabric with both
- Just fabric

These mockups were created using the setup in Figure D3, where the wood could be inserted through a sewn "pocket" at the bottom of the fabric.

Fig. D3. Fabric with stakes and wood mockup for Wagner Farm testing

The design was tested for wind-resistance and observed for its interaction with the wheel and side of the coop. Based on the wind outdoors at the farm, we were able to measure the airflow in front and behind the design using an anemometer. In addition, this design was tested with and without stakes installed in order to test the effectiveness of the wood weight. It was also observed qualitatively that the length of the skirt would not interfere with the movement of the trailer.

Additionally, we asked Blake for his input regarding certain ideas and parts of the design. The questions include thoughts about various design aspects of the coop, as well as how user-friendly our ideas are.

Results

This section is split into the testing done on campus at the shop and the testing done in person at Wagner Farm. Each part contains the measurements taken of air flow in front of and behind the mockups tested. Images and short explanations of them are provided of the testing setups. The results also include the project partner’s answers to questions posed at the testing session.

On Campus

While on campus we tested the feasibility of four different design ideas: fabric with wood, fabric with stakes, a sliding “window”, and a straw/paper towels mockup. Our tests included blowing air at the mockups via a fan and measuring the airflow in front of and behind the mockup.

Figure D4 depicts the efficacy of the rolling straw design being tested by utilizing the anemometer to measure the air speed behind the mockup. When doing this testing, the team additionally observed the movement and sound of the design under the wind of the fan.

Fig. D4. Measuring wind speed behind the straw mockup

Table I includes the quantitative results from testing the mockups under the wind of the fan and the qualitative results from observing their physical reaction to the wind.

Table D1: Mockup Testing Results in front of the Fan

	Fabric with Wood and Stakes	**Window**	**Rolling Straw**	**Fabric with stakes**
Airflow In front of mockup (m/s)	2.1	2.1	2.1	2.1
Airflow Behind mockup (m/s)	0	0	0.5	0
Observations	Gets pushed back (not as much as the straw though), wood not heavy enough. Wobbles, but slower than the straw.	Cardboard wobbles back and forth but is not significantly pushed backwards.	Gets pushed back to the middle pole of the mockup. Wobbles the most.	gets pushed back, all the weight from it is from the stakes (it balloons)

The noise of the mockup was not noticeable over the noise of the fan.

Fabric with wood and stakes: this design would be effective at minimizing air flow behind the fabric, as the air was moving at 0 mph behind the fabric, however there was airflow under the fabric when it was pushed by the wind.

Fabric with wood: this design was still effective in decreasing airflow to zero; however, it moved around extensively since it was not anchored to anything, and the area which became exposed still had a lot of airflow

Straw: this model does very little to block windflow due to holes in the design. Additionally, with only the wood weights at the bottom, it flapped around and was moved backwards by the wind very quickly, similar to the model of fabric with wood.

Window: this model decreases the airflow effectively in that it is a rigid obstacle against all wind; however, we doubt that the friction force which holds the cardboard would be sufficient to hold something sturdier but heavier. This is because a wooden section, for example, would require much more friction to stay in place- with wear over time, there is the risk that friction fit will lose effectiveness and the section falls.

Feedback from Wagner Farm

Blake is hoping that the skirt can be made of durable and hygienic materials (no velcro, wood touching the ground, *etc*.). He also was hesitant to use stakes, since they could break the design if not taken out each time before the coop is moved. He was also hesitant to have the skirt be built as a community project, since the materials and people would be somewhat unreliable. In addition, he had some recommendations for materials to build the skirt out of, as well as ways to insulate it. He also noted that requiring two people to store the skirt in order to move the trailer or pack it up for summer is very feasible, but that just needing one would be better.

Methods of Connection to the Coop

- Blake stated his concerns over the velcro becoming dirt-filled and unsanitary over time and thought about what type of adhesive would be used. While he said he was not opposed to the idea, he stated that hooks are low maintenance.

Methods to Prevent the Skirt from Moving

- Blake was very against using stakes or anything which could be forgotten to be detached from the design and break if the trailer were driven away without removing it.
- Wood would not be ideal according to Blake because of the humidity and hygiene concerns. The wood could get wet and rot or be destroyed by the chickens or other animals. He would like to have a more durable material.

Materials Considerations

- In regards to creating the skirt as a community project, where community members work together to weave a skirt from wheat husks, Blake was concerned about the consistency of wheat crop growth year to year– some years, shorter crops would make it more challenging to weave. He was also weary about allowing the public to create artwork for reasons of respect and animal welfare.

- Blake has researched thermal paint protection before but has been wary of the costs. He specified that this was called Isonem Thermal Paint, and costs around $200-$300. This value would be at the top of what he would consider.
- Rubber is relatively durable and copes well with the humidity and cold temperatures. However, it is a poor insulator when it comes to keeping the chickens warm. Wood can lead to rot and break easily, so it is not ideal.

Convenience of Storage/Use

- Blake said that it would be fine if two people were required to move the skirt; that seemed to be his default number. He said that two people are working at the farm at almost all times, so finding someone shouldn't be a problem. He also noted that being able to move it with one person would be nice, but not necessary.

For our mockup testing at Wagner Farm, we observed that the strength of the wind often picked up enough to blow the entire skirt backwards. At one point during testing, the wind picked up to 5.9 m/s, which easily caused the skirt to become ineffective without stakes. Table B2 includes quantitative measurements of the airflow in front of and behind the mockup. Behind the mockup, airflow was measured near the upper half and near the lower half of the mockup, which allowed additional testing of their movement resistance to the wind.

Table D2: Mockup Testing Results at Wagner Farm

	Fabric with Wood and Stakes	**Fabric with wood**	**Fabric with stakes**	**Fabric by Itself**
Airflow In front of mockup (m/s)	0.9	0.9	2.1	2.3
Airflow Behind mockup (high) (m/s)	0	0	0	0.3
Airflow Behind mockup (low) (m/s)	Minimal space here; N/A	Minimal space here; N/A	Minimal space here; N/A	2.0

Figure 5 depicts the lower half of the "Fabric by Itself" design being tested with the anemometer. The designs without stakes would be greatly pushed back under the force of stronger winds, allowing wind to pass through from under them.

Fig. D5. Testing Fabric without wood or stakes with anemometer

Fabric with wood and stakes: We found this design to be the most effective as the stakes kept the fabric from blowing up when the wind was strong. However, since Blake informed us that he prefers us not to include stakes in the design because he may forget to remove them all and cause the product to break, we must consider incorporating simplicity and fewer moving parts in future designs.

Fabric with wood: This design would have been more effective if the weight used was heavier, since when the wind became stronger the tarp blew backwards towards the tires and let air go into the coop. Blake suggested using a metal pipe instead of wood. It could also be more durable and effective in avoiding the design catching in the tires of the trailer.

Fabric with stakes: This design was more effective than the design with only wood, since the stakes prevented the fabric from blowing backwards. However, without the wood, the fabric was pushed inwards/bubbled when the wind was strong. Having some sort of pipe or bar running through the bottom of the fabric would prevent the inwards bending.

Fabric by itself: This design was overall very ineffective, it was blown around extensively by the wind and didn't fully stop the airflow at any height under the trailer.

Discussion

On Campus Testing

During the on-campus testing, we learned that there must be some sort of weight on the bottom of the skirt in order to weight down the skirt; otherwise it blows around too much in the wind. While the fabric with stakes, fabric with wood, and "window" designs effectively stopped the airflow, the straw design still allowed for a large influx of air. Additionally, we discovered that the hung "window" is likely not strong enough to support its own weight, and is therefore feasible as a design. As such, we intend to move forward with a fabric design weighted down by either wood, stakes or both, since we believe this will be an effective way to stop the flow of air.

Wagner Farm Testing

The main takeaways from the mockup testing at the farm involved revisions to the final design based on our project partner's concerns. One example is the use of stakes– he preferred a solution without stakes because of the high risk that they would be forgotten in the ground and lead to destruction of the design. This piece of information will guide our design process away from a solution that is anchored in the ground for increased rigidity. Additionally, in the materials recommendation from Blake regarding insulation, we learned that rubber is not adequately insulating so we will be looking for alternative options. These considerations impact the design requirements surrounding the usability of the design.

Conclusion

Moving forward, we intend to create a design which is user-friendly for the farm staff, is durable and incorporates insulation effectively to keep the chickens protected from cold air. This includes not requiring the user to roll up the design each time the coop is moved (only when storing it for the summer) and not requiring the user to remove stakes, *etc.* from the design which could be forgotten and break the product if the trailer is moved while they are still attached. Instead, we intend to keep the skirt close to the ground by weighing it at the bottom, most likely with a metal pipe. However, we must consider methods to prevent the skirt from being pushed back and allowing wind to flow underneath. With regards to materials and insulation, we will aim to integrate the insulation within the design/ fabrics.

Appendix E: Safety Evaluation

The safety evaluation identifies how our prototype will be used by users (including unintended uses), potential safety risks, and design modifications to address those risks. This was the safety evaluation of our initial prototype, which shares the same key features of our final design, with the exception that it lacks insulation.

Note the following rankings for Table E1 below, which were used to evaluate the frequency, impact, and risk rating of various design failures and scenarios.
Column 3 – Frequency
1. Quite rarely
2. Once in a while, but much less than half the time
3. About half the time the design is used
4. Almost every time the design is used

Column 4 – Impact
1. mild annoyance to user / superficial but not functional defect on design
2. really irritated user / damaged part of design, still functional
3. minor injury to user / part of design doesn't work and must be repaired or updated
4. serious injury to user / none of the design is usable

Table E1. Safety Evaluation

Scenarios & Design Failures	Implications	Frequency	Impact	Risk Rating	Design Options
The fabric gets a hole in the middle of a section	The section is broken, must be rebuilt. While the design may still be functional, it will be more likely to further be damaged as the hole becomes a weak point. Additionally, water would be allowed to enter the design easily and possibly compromise the	1	3	3	use durable fabric to ensure that the fabric is sturdy and will be less likely to rip

	insulation.				
The fabric rips after getting caught on the ground	section is broken, must be rebuilt. Depending on the severity of the rip, the design could be entirely broken with the insulation spilling out, or it could just be a minor tear with the same implications as the failure above.	2	3	6	Add a wider pipe by the front wheels so that it bounces off and/or add hooks so that the front portion can be easily lifted to be out of the way.
Upper pipe falls down (seem rips)	Product not as durable in the wind, could potentially rip/ruin the whole product; need to fix	1	3	3	The product can be sewn with especially durable thread in multiple runs with lots of backstitching
Whole product falls off of the coop	The design will fall off coop and need to be reattached	1	3	3	Attach the design very well in many places to minimize risk of falling. This includes using grommets attached to multiple hooks on the coop.
Rain water soaks the fabric and insulation, possibly causing freezing/ rigidity	Could freeze product or ruin the insulation	1	2	2	Waterproof the skirt, with a spray or just naturally by using a waterproof fabric
The corner zippers are not unzipped at all before moving the coop	This could allow the skirt to get caught under the wheels and lead to ripping the design	3	1	3	Adding a wider pipe to the front by the front wheels so that it bounces off

The corner zippers are not zipped after moving the coop	The design will flap around more in the wind and possibly block the wind with less efficiency	2	3	6	Having the pipes themselves. be heavy enough to block out most of the wind without being zipped.
The chickens peck at the fabric, causing exterior damage	Design is damaged and should be repaired; not detrimental to product unless hole is very wide A hole could allow water or bugs to get in the insulation	1	3	3	Ensure the fabric used is super sturdy/durable so that the chickens cannot cause too much damage
The attachment mechanism (Hook or grommet) fails and leaves the design hanging partially.	The design will still block some wind, but will need to be reattached	1	3	3	Attach the design very well in many places to minimize risk of falling. This includes using grommets attached to multiple hooks on the coop.

Appendix F: Design Review Summary

Introduction

During our design review, we presented our project by answering four questions: “What is it, what does it do, how do you use it, and how does it work?”. We used detailed illustrations as well as verbal descriptions to help our audience visualize our concept. Our design is a trailer skirt utilizing waterproof fabric folded in half and sewn to have pockets for heavy pipes such as PVC or steel and larger sections containing insulation. We received recommendations on how to improve pre-existing components, how to maximize ease of use of the design, and how to make sure the design is suitable for all weathers.

Table F1: Feedback Summary

Choice of Components	Weatherproofing the Design	Maximizing Ease of use	Other feedback
-A metal pipe will provide more weight to resist the wind. -Determine whether the thermal paint is safe for chickens or not -It may be more likely wind will get in if you have multiple sections -Insert a rigid barrier around where the wheel would hit -Make the material black so it’s absorbing sunlight -Look into using velcro -PVC doesn’t rust but can warp, aluminum is expensive but doesn’t	-Keep insulation from molding -Prevent material from getting wet or freezing -Waterproof skirt -Insulating material never gets wet, or makes sure it dries quickly – tricky balance. Look at camping equipment, outdoor patio furniture, cushions -Consider flash flooding and snow	-Ask Blake if he prefers to store the whole product or just roll it up -Zippers: snaps that can be undone. Doesn’t break, releases → what if it doesn’t line up? -Add extra material so the zipper will always work and won’t have issues lining up -Inside of skirt is white, fold it up halfway during the summer → gives shade and allows air to go into the coop	-Chickens may be able to go under the fabric and Blake could then drive away with chickens under the coop

rust, steel is cheap -Use hollow tubes instead of solid rods because they're stiffer; prioritize larger diameter but hollow -Add a third pipe/rigid portion at the top or spaced magnets so air can't enter through the top			

Action Plan

Having gathered feedback from our peers and professors, our team will now focus primarily on improving the choice of components used in our design based on research and the feedback received. We will look into options for different types of fabric, metal vs PVC pipes including different types of metals, and ways to weatherproof our design.

Appendix G: Instructions for Use

The CluckCurtain is intended to be attached both in the winter and the summer. However, it's intended to be folded into a storage position during the summer while most of the skirt is left down in the Winter. The following are the steps to follow when using the CluckCurtain. These steps are divided into steps for summer storage and steps for winter use.

Folding for Summer Storage

1. To fold up
    a. Unzip all zippers connecting sections of the skirt
    b. Lift the bottom pipe to bring it even to the top of the skirt and hook the layer of the grommets below the pipe into the row of hooks (Figure G1)
2. To unfold
    a. Unhook the top grommets from the hooks and fold the design back down
    b. Zip each corner of the coop closed

Fig. G1. CluckCurtain unfolded and then folded for summer storage

Folding for Moving During the Winter

1. Unzip the bottom half of the two front corner zippers
2. Lift the bottom pipe to bring it even to the top of the skirt and hook one grommet from layer of the grommets below the pipe into the row of hooks (Figure G1), leaving the rest hanging
3. Move the Coop
4. After arriving at destination, unhook the grommet at the corner and re-zip the corners

Maintenance

1. Cleaning
    a. If the design becomes dirty, spray one or both sides with a hose
    b. To reach the inside, fold the design up as in Figure G1 and hose down the inside also
2. Repairs
    a. If the fabric becomes damaged or in need of repair it will likely need to be replaced by following the instructions for construction
    b. If the insulation of pipes need to be replaced:
        i. Take out the seams connecting the design to the zipper with a seam ripper

ii. Take out old pipes/insulation and insert new ones
iii. Sew the seam taken out back together

c. If the zippers need to be replaced:
   i. Take out the seam connecting the zipper to the design with a seam ripper
   ii. Replace with a new zipper and sew it in

Appendix H: Instructions for Construction for the CluckCurtain

Introduction

The CluckCurtain addresses the challenge of preventing cold wind in the Winter from flowing into the mobile chicken coop through its grated metal floor while still allowing the coop to be conveniently moved. The skirt is flexible or easily folded up to prevent permanent damage from being dragged on the ground during movement, an issue encountered with a previously tried solution of attaching plywood to the sides of the coop. The skirt is additionally designed to be weather resistant and provide slight insulation.

The CluckCurtain consists of waterproof fabric folded in half and sewn together into four sections, with an additional one inch margin at the bottom and four inch margin at the top to allow for the installation of grommets. The four sections alternate in size, with two for the insertion of a 1.3 inch diameter metal pipe and the other two for the insertion of insulation about one inch thick into the skirt. The two sections for the pipes are spaced 9.5 inches apart. Once the insulation and pipes are inserted, the sides of the skirt are then sewn shut with zippers sewn onto the vertical edges. To attach to the coop, the skirt will be pulled taut with screws installed through the grommets. There will be separate instructions for the section of the skirt installed on the front of the coop to accommodate the hitch.

These instructions will lead you through the process of safely and efficiently setting up the Flexi-Skirt at the Wagner Farm. The instructions are tailored for the older chicken coop, and widths and heights might change for different sized mobile coops. These instructions will require manual labor as well as the use of power tools. It should take around two hours to construct this prototype. Always wear safety glasses, tie up long hair, and avoid touching the rotating drill chuck and bit when using the power tools necessary to construct the CluckCurtain.

The instructions are divided into the following sections:

1. Materials and Equipment
2. Creating the CluckCurtain
    a. Preparing the fabric
    b. Installing the grommets
    c. Installing the pipes and insulation
    d. Installing the zippers
    e. Specific instructions for the front side of the coop
3. Installing the CluckCurtain

Materials and Equipment

The following table lists all materials required to build the Flexi-Skirt.

Table H1: Bill of Materials (Full product)

Material	**Specifications**	**Quantity**	**Cost ($)**
Waterproof Tear-Resistant Fabric such as: Ottertex® Waterproof 70D (1.9oz) PU Coated Nylon Ripstop	2 pieces 16 feet 2 inches long, at least 4 feet tall. 2 pieces 8 feet 4 inches long, at least 4 feet tall For an additional margin of error, an extra inch can be added to the length when cutting the fabric. Fabric from the provided site is sold with a height of 62 to 63"	17 yards (Required for a full size product)	118.83 (6.99 / yard) ($6.29 / yard for 15-49 yards)
Zippers	2" x 0.5" x 31"	4	9.99
Pipes (if steel) 1.5" OD x 0.065" Wall x 1.37" ID Carbon Steel Round Tube	1.5" outer diameter 100'	5, 20 ft each	685.2
Pipes (if PVC) 1-1/2 in. x 10 ft. PVC Schedule 40 DWV Pipe	1.5" outer diameter 100'	10, 10 ft each	89.8
Insulating material https://residential.havelockwool.com/products/r20-batt-insulation-24-o-c	23.5" x 46.5"	2 Bags (8 batts each)	300
Grommets Grommet set including press and hole punch 500 Piece Grommet and washer set	10mm (⅜") Inner diameter, with an outer diameter of 9/16"	Around 200	Press and hole punch set: 34.99 500 Piece set: 9.99
Hooks Set of 50	2.2" screw length	Around 50 (Box of 50)	24.99

amazon.com/ADIIL-Windproof-Hanging-Outdoor-Christmas/dp/B0C411LS6L			
Durable sewing thread	n/a	1 roll	10.99
Phillips flat head screws McMaster-Carr https://www.mcmaster.com/90065A251/	⅜" Head Diameter ID: 90065A251	Around 100 (1 pack of 100)	18.09
Washers McMaster-Carr https://www.mcmaster.com/90107A011/ https://www.mcmaster.com/90107A029/	⅝" Outer diameter 90107A011	Around 100 (1 pack of 100)	4.55
	7/16" Outer diameter 90107A029	Around 100 (1 pack of 100)	8.06
Washers McMaster-Carr https://www.mcmaster.com/94051A210/ (Alternatively, washers could be stacked)	ID: 0.203" OD: 0.750"	100	$171.00
		Total Cost Without Tax (if using PVC):	788.67
		Total Cost Without Tax (if using metal pipes):	1384.07

*+ hooks for fastening when folding in summer

Note: See Bill of Materials in the report for detail on cost, part numbers, and part numbers.

The following tools are required to construct this device:

- Drill
- Drill bits (3/16" and a screwdriver head)
- Grommet press tool (for ⅜ inch grommets)
- Grommet hole punch or hole punch drill bit (8mm or 0.315 inches)
- Measuring tape
- Scissors
- Sharpie
- Grommet kit plastic disk
- Chalk (for marking lines on fabric)

Directions

1. Preparing the fabric

In this section, the user will cut the fabric to the correct side and hem the top with a rolled hem.

a. Cut fabric to 16 feet 2 inches or 8 feet 4 inches long depending on whether the section fits the long or the short side of the coop.
    i. An additional inch or two can be added to this cut to increase the margin of error for construction.
b. Cut to a width of 56 inches (The fabric should be around 62 wide tall in the batt)
c. Fold the fabric such that the resulting skirt is 28 inches tall.
    i. If only one side is waterproof, make sure it's the side on the outside after folding.
d. Hem shut the top of the fabric with a rolled hem

2. Installing the grommets

In this section, the user will install grommets to the top and bottom of the design.

a. Measure and sew a 1 inch seam allowance at the bottom of the fabric (such as in Figure 1)

Fig. H1. Seam allowance on bottom edge

b. Mark white dots along the middle of the sewn edge of the fabric to the end, each spaced out 6 inches with a sharpie
c. Place the grommet kit plastic disk under the fabric and hold the fabric down with one hand
d. Drill a hole into the fabric on each mark using the 8 mm (0.32 inch) diameter hollow drill bit provided with the grommet set (Fig. H2)

Fig. H2. Hole being drilled for grommet

e. Place a grommet into the grommet hole punch, and punch the grommet into the fabric at one of the marks
f. Repeat steps c-d for each mark
g. For the top side of the fabric, sew a 3 inch seam allowance.
h. Repeat steps c-d along the top margin

3. Preparing for and Installing the pipes and insulation

In this section, the users will sew the horizontal seams to incorporate insulation and the pipes into the design.

a. Measure 2.5 inches above the top edge of the bottom margin and mark a straight line from each end of the fabric to sew for the pipe as shown in Figure H4.
    i. If a bigger or smaller diameter pipe is used, the measured section can be increased/decreased to accommodate the size of the pipe.
    ii. Sew the folded fabric along the marked line
b. Measure 9.5 inches above the top edge of the newly sewn section and draw a line for the bottom edge of the section for the second pipe.

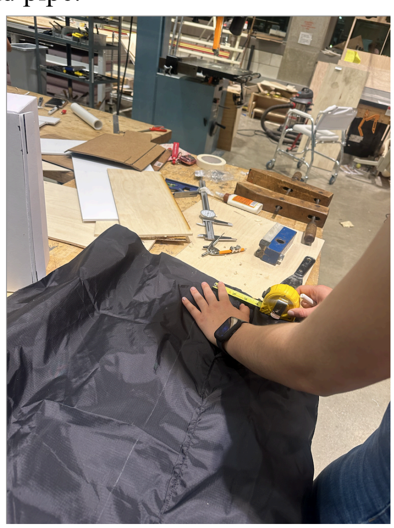

Fig. H3. Measuring margins

Fig. H4. Line for section being marked

   i. Sew the folded fabric along the marked line
c. Measure another 2.5 inches above that edge and mark a straight line
d. Sew the fabric and connect both sides along the line
   i. There should now be four sections in the fabric and two margins with the grommets. The sections for the pipes should be 2.5 inches wide. The sections for the insulation should be 9.5 inches wide.
e. Cut two of the 1.3 inch diameter pipes to a length 1 inch less than that of the fabric.
f. Insert the pipes through the 2.5 inch holes through the entire length of the fabric.
g. Insert insulation into the remaining two sections
   i. For the insulation, cut to the width of the section. Insert around 1 inch thick of insulation.
   ii. Slide the insulation carefully with one hand placed flat against the surface so that it stays flat.

4. <u>Installing the zippers</u>

In this section, the zippers will be sewn to the sides of the fabric.

a. Place a zipper on the edge of one of the pieces of fabric. Sew the zipper onto this edge
   i. Ensure that the bottom of the zipper is at the top of the fabric (The zipper zips downwards instead of zipping upwards).
b. Sew this zipper onto the piece of fabric on the adjacent section
c. Repeat steps a and b for each piece of fabric to connect all of the sections together

5. <u>Instructions for the front side of the coop</u>

In this section, the user will construct the front side of the coop (which is slightly different from the other sides)

a. Cut an 8 foot 4 inch long section of fabric to a width of 56 inches.
b. Cut this section into a 4 foot 4 inch section corresponding to the platform in front of the entrance for the coop and two other sections corresponding to the left and right side of the platform.

    i. If the platform is directly in the center of the front, then these two sections will be 2 ft long.

c. Follow steps 1-5 for the two 2 foot sections.
d. The next steps refer to the 4 foot 4 inch section.
e. After folding the fabric in half, measure and mark at the top side 7 inches from both sides of the skirt. From these two marks, draw a rectangle 2 inches wide.
    i. This rectangle should be 3 feet 2 inches long to match the width of the front platform.
f. Cut the rectangle out of the fabric.
g. Sew the top of the fabric shut, including the cut edges.
h. Follow steps 1-5 for the fabric
    i. When installing grommets, install three grommets on each side of the top margin, each grommet 3 inches apart. Install the grommets on the bottom edge to align with the top edge.
    ii. When installing insulation, make sure to cut the insulation to accommodate the space left for the front platform of the coop.

Installing the Flexi-Skirt

1. Installing the CluckCurtain

a. Align the zipper to the corner of the coop.
b. Align the bottom edge of the top seam allowance
c. Take a screw and first slide on the 7/16'' washer and then the larger 5/8'' washer.
d. Pull the skirt taut and screw in the screw into the grommet nearest the zipper.
e. Take the next grommet and pull the skirt taut.
f. Screw in another screw with washers.
g. Repeat steps e-f until the next corner of the coop is reached
h. Repeat steps a-g for the two sides and back of the coop.
i. At the front of the coop, install the two shorter sections at the left and right corners of the coop.
j. For the section around the platform, align the zippers to the installed shorter sections and place the front platform in the cutout.
k. Install the screws through the grommets and connect the three sections using the zippers.

2. Attaching hooks to the coop

a. Mark 2'' above either grommet closest to a zipper
b. Drill a 3/16'' hole into the wood where the hook will attach
c. Place the plastic anchor (included with the hook) into the hole and gently hammer it in
d. Screw the hook into the plastic anchor by hand and orient so the clip is facing upward
e. Repeat a-d for every other grommet, as depicted in Figure H5

Fig. H5. Attachment of CluckCurtain