Pastured Poultry Egg Project

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January 20, 2025

1 Introduction

This is a project to document all the necessary parts for raising layer hens on pasture, and trying to optimize for profitability. It is not a strictly scientific paper, more a review of literature and a documentation of all the little details that are important for either raising pastured poultry for profit or experimental design involving pastured poultry. Small flocks of hens are often kept in rural Nova Scotia, free-range or small runs, and the eggs are marketed on roadside stands, usually using a cooler and the honour system for self-serve sales. These eggs are perceived to be healthier and, in fact, may be higher in vitamins and omega-3s [7]. Profitability is generally not a concern as most producers keep the birds as a hobby; however, I believe there is potential for a profitable enterprise. There are many online blogs and even some scientific papers on pastured laying hens. However, many of these assume that the reader is already a chicken farmer or is only keeping them for a hobby. Others give the basic idea, but leave the reader to work out the details. [4] My objective here is a detailed explanation of what is needed to start up a pastured layer operation, common pitfalls or at least errors that I've made. Finally, I will try to keep advice based on real experiments and published research instead of arguing from "it worked for me, so it's the best" style rhetoric. This is also an evolving document, supplemented by the rest of the files in this Git directory. I aim to document a more profitable method of raising poultry, following the results of my own trials and experiments.

There are two basic methods for raising chickens in pasture.[5] You can have a mobile house for the birds to roost in at night and a portable fence around that. This is moved through the field manually once a week-ish. The second is to keep the birds in a tractor with walls and roof of at least mesh

but no floor. They have access to that patch of field, and it's moved every day. There are a few other options, a permanent coop and fields around it that are rotated through, many tiny coops spread over a large field. The need for fresh ground is key, chickens will rapidly destroy any plant/sod if the land is not given a chance to recuperate. What the critical stocking density / rotational interval is not well established. British free-range egg producers require 1 acre of run for 1000 birds [2], Australian regulations require no more than 10000 hens per hectare, but 1500 birds per hectare is seen as best practice [3]. Some advocate for no more than 50 birds per acre, which was considered best practice before modern fertilizers, 50 birds being potentially over fertilizing the field for grain. [6] Very low stocking density seems to require movable shelters. 10000 hens per hectare is one bird per m2 which will assuredly kill all plant life.

Profitability means keeping input costs low. The sale price is generally fixed by the going rate in grocery stores for direct marketing, though depending on the market a pasture raised egg can sell for a premium over an egg from a large scale indoor layer egg farm. The vast majority of the cost is feed and labour, but capital for coops, washing eggs, buying/hatching hens, and marketing also plays a role.

2 Equipment and Capital

2.1 Coop and net fences

This requires a mobile coop and a electric fence net. The mobile coop is often tractor pulled, wagon style. I don't have a tractor and unless you have one for another purpose I can't see this paying off. Regardless of the solution, the chickens will spend quite a bit of time in the coop. Every night they will be inside and they will stay in on rainy days. In the winter rain, snow, strong wind will make them choose to stay inside.

There are special poultry nets but I was able to train the chickens to both a sheep/goat net and a 6 wire only horizontal line electric fence. Chickens aren't really very susceptible to electric fences, they only sometimes get shocked. But they get shocked enough to eventually avoid the fence. They will get shocked much more readily in the rain.

2.2 Chicken tractors

Some broiler operations use large tractor towed chicken tractors that are dragged on the ground. And it appears some are used for laying operations

too. [6] I tried to build something like this and the skids destroyed the grass, though my skids where plywood and I used a winch to move it instead of a 30 hp tractor. Smaller diy ones abound on the internet as do prebuilt ones: `https://goodnatureecofarm.ca/shop/equipment/shelters/`. The applicability of any of these coops is location dependent. Wind and terrain are the main problems. In the must haves section I'll talk about what to look for.

2.3 Chicken shelter design must haves

Ventilation is important for avoiding respiratory problems, and maintaining proper humidity. A chicken needs 2-8 liters of air change per second in a barn setting[9]. I have $0.5m^2$ of open area and 22 chickens (tractor jan 2025). Assuming 44l of air exchanger per second, I have a velocity v of $0.088m/s$ or about $0.3kph$.

$$A \cdot v = Vol$$

I haven't measured the air speed through the vents, but that seems likely to be within these guidelines. I do open up larger air vents in the summer to avoid over heating.

Overheating in the summer is also an issue, but usually not a huge problem in Nova Scotia. The roof should be made of a light colored material and opaque to provide shade. Heat stress typically starts at 28c. [1][10] I have used 6 mil poly silage tarps with the white side up without an issues, even after including transparent greenhouse fabric on the walls of the coop.

Wind flipping is often overlooked on internet designs, and this is difficult to design for because the tractors must be kept light for movement. The first coop I built needed to be staked down with guide-wires in the wind, which was not ideal and complicated the moving process. An estimate of the wind speed needed to flip a coop can be found by looking at the torque provided by the wind blowing on the wall and the restoring torque caused by gravity and the center of mass.

$$\tau_{wind} = \frac{h_{coop}}{4} C_f \rho u^2 A_{sidewall}$$

Where C_f is the drag coefficient of the coop, likely about 1 for non-streamlined coops. A is the side wall frontal area, or projected area. It's the length along the ground times the height to the roof peak for a rectangular coop with peaked roof. ρ is air density, u is wind speed. h_{coop} is the height of the coop

$$\tau_{gravity} = \frac{1}{2} g w_{coop} M_{coop}$$

Here w_{coop} is width of the coop, M_{coop}, and g is acceleration due to gravity. Setting the torques equal, you can find the wind flipping speed. I have an example spread sheet in this folder you can look at. I should be good for 100 kph winds if my chicken tractor weighs 200 kg. In practice, we can get wind above 100 kph where I live and I'm not sure it's 200 kg, might be a little less, so in high winds I park two tractors next to each other so that if one tries to flip it runs into the other one. This tractor hasn't flipped so far in 6 months of use. Pants and suspenders approach is recommended here, if the tractor flips in a storm all the chickens will be gone, it will be like restarting from square one. I may add lashing system to my tractors so that they can be tied together for extra security in high winds.

The coop also needs to be reasonably watertight and not collapse under heavy snow. I have had good luck with 6 mil silage tarp attached to a wood frame with wood battens. Battens are cut about 2 mm thick on a table saw and holes for screws pre-drilled. Then they are screwed through on the plastic to seal it to the frame. Small screws work great and don't pull out. Nail and staples are faster but they always seem to pull out. Plastic seams and holes can be sealed with "tuck tape" or the tape used for tyvec house wrap. Chickens do not seem to peck and destroy this material though I have had problems with them destroying styrofoam. I did have muscovy ducks once that liked to sit on top of the coop and they did rip up the silage tarp plastic with their claws. The coop should also be chicken tight, only access through the proper doors. Having the option to contain all the birds is important for bringing in new birds, moving the coop, etc even if you do let them range in a fenced area. Plastic net works fine to contain them, chickens aren't usually very motivated to escape.

Manure management is important, do it wrong and it will cost you a lot of time. The options are: Hard floor with bedding/litter, slat floor to let the manure fall through, or no floor and move the tractor daily. I have tried all three. The hard floor with litter is fine if you have lots of litter. Straw or wood shavings work fine, though wood shavings are more absorbent and where I am slightly cheaper. Eventually they will all need to be removed, and as they accumulate they are very heavy. The slat floor has a few caveats. First, it needs to he skirted on the edges of the wind will blow up into the coop and the chickens may get cold from late fall to early spring. Chickens can handle the cold pretty well but the wind is hard on them. Also these

floors still need to be scraped out. It's not terribly difficult if you have it designed for that but likely not all the manure will fall through. Below freezing temperatures is really bad for this, the manure builds up and is very difficult to remove until it thaws out. The no floor option is great in the summer as long as the ground isn't too bumpy. I added skirts on the bottom of mine, but I think that's probably redundant except at the back. In the winter heavy snow can make it hard/impossible to more the tractor. Then you may need to add litter. The low temperatures actually make the coop pretty clean though as frozen manure doesn't stick to the chicken's feet.

Water is typically supplied daily when the eggs are collected. Nipple waterers are great in the summer though I found the horizontal nipples broke all the time but the vertical nipples work reliably. In the winter the vertical nipples will freeze easily. An electric submersible heater will keep them open but this requires a large electrical power source. I tried making an insulated bucket with nipples on the bottom and filling with hot water once a day. The water stayed liquid but the nipples froze. Typically freezing doesn't hurt them however, and they work fine once thawed. A simple bucket filled with hot water daily works ok in the winter, the trick is to find something that can be easy to bang ice out of if it freezes overnight. In cold weather the chickens don't need continuous water access.

Feeders are usually free choice, the birds can eat whenever they choose to. Cone feeders and open pans of feed often get spilled or the chickens scratch out grain and leave some on the floor. Because feed is a large portion of the cost minimizing waste is important. Another option is the beak activated feeder, where a paddle hangs down from a bucket and only when it's knocked or pecked does it move and let fall a small amount of grain. I tried this and the chickens easily learned how to peck it. They also liked to peck it more than they liked to eat so grain would fall that they wouldn't eat. These feeders are promoted as rat proof but the grain on the floor attracted rats in my case. A head hole feeder has something like a 90 degree pip bend set into the wall of a bucket. The chicken can put it's head inside and eat the grain, and as it is removed more flows in from the sides. These are really good for eliminating waste, but a rat could figure it out, this what I'm using now (Jan 2025). Another option is the treadle feeder. These are rat proof as the door is activated by the weight of a chicken. I have never used one because they are expensive to buy new, and the usually don't hold that much grain. A future project is to make a diy treadle type door for a head hold feeder.

I have a cad file for a 3d printable pipe bend. Then I use a press fit into the side of a square plastic bucket. Any feeder should have a large capacity so you're not refilling everyday. My feeder holds about 18 liters of grain,

and I'd prefer more like 40-45 liters. That way I could add a full 20kg bag of grain without having to deal with leftovers in the bag. The feed and water are heavy, so in my next tractor design I will put them near the wheels, and the next boxes on the other end, that will make the tractor easier to lift and move.

Nest boxes for the chickens to lay in don't need to be fancy. A cubby make from plywood and lined with dried grass is fine. Roll away nests exist, where the eggs roll into a storage area once laid, but this uses gravity and seems hard to implement in a mobile coop. Hens easting their own eggs can become a problem, but so far I haven't see it. It is a learned behavior so you should be ok unless one hen starts. Thin shells that crack when a chicken steps on them might contribute to a chicken learning to eat eggs. Another option is buckets screwed with the bottom of the bucket to the wall and some sort of front lip. I like this idea if you can find cheap/free buckets because it's light weight and I think rats have a hard time climbing the slippery plastic. The chickens like them fine, I have one nest like this and it is always laid in.

Whatever next box is used, it's best to keep it off the floor about 60 cm. That way the don't feel cozy enough to lay under it, but it's not high enough to be a good night time roosting spot. The nest boxes should be far from the feeder and water and darker than the rest of the coop. Curtains (I used silage tarp scraps) can help make the nests darker. Fake eggs can encourage them to lay in the nests. I use 3d printed red eggs. Fake eggs are also a good way to know if you have rat problems. Rats will try to bring a fake egg away to eat, and the fake ones are easier to move (lighter) than real ones. Laying on the floor is a common problem but usually the chickens can be trained to lay all in the nests. An exception to this is if you allow the chickens to range in a fenced area. Then they may choose to lay anywhere outside.

Lighting is necessary if you want to the hens to lay through the winter. Solar powered lights are ideal, next best is battery lights that you charge daily. If the light does not come on and off automatically you will need to visit the coop at least twice a day. This may be time consuming depending where in the field the coop is. The light does not need to be particularly bright, 2 watts for an LED is usually enough. I have a light and temperature logger from another experiment to validate. Chickens need about 10 lux, or 10 lumens/m2 to extend the daylight.[8] For a coop on the range of 100 sqft as is discussed in this paper, this is a 100 lumen light. LED lamps usually provide 75-110 lumens per watt, so a 2 watt LED lamp is fine.

2.4 My coop trials 2021-2025

I will try to give a review of all the coops I tried, and the rational behind them. These were not controlled experiments but sort of a iterative learning process. Note that until 2024, the flock was small 6-10 hens, and for personal use only with no sales.

The original coop was 4ft x 7ft with a slat floor made from 1 inch wood strips and 1 inch gaps. The height was 4 ft with shallow sloped shed roof. Walls were a thin wood frame with silage tarp covering. There were 4 treated decking boards on the bottom for skids, a man door and a chicken pop hole. Nests were a bucket and an old tire on the inside. I used a feeder with a pecking activated flap to release grain. Water was simple bowls outside. I had 5-8 hens in it. I used a 5 wire electric fence around it and then a goat electric net fence. The good:

1. It was light enough to move by hand, lifting one end and dragging.
2. It was cheap.

The bad:

1. It was light enough to flip in the wind, I needed to stake it down every time with two guide wires.
2. The slats weren't strong enough to walk on so humans getting eggs would sometimes crack the floor.
3. The slats would get caught on sticks when moving the coop
4. The fence took a long time to move and setup, 30-60 min.
5. The grain fell between the slats and the chickens wouldn't be able to eat it. This attracted rats, who ate grain and sometimes eggs.
6. The slats needed to be cleaned as manure accumulated on top, especially in freezing weather.

The next coop was 4ft x 10 ft in 2023, only 2 ft tall gentle shed roof, but with 3 ft legs to keep it up in the air. I used the same frame of light wood construction with silage tarp covering it. The Floor was OSB and the 10 ft side both had doors the whole length so that the manure could be scraped out both ways. Water as 2l bottles inverted with a bowl at the bottom, 3d printed. Feed was a head hole feeder inside.

The legs were to keep it out of rat reach, but them promptly broke off when I tried to move it on rough ground. There was nothing good about this coop. Once it broke I had to use it on the ground and it was terrible to move, just barely dragable by hand. Scrapping out the manure was a pain. I didn't use it for long and went back the previous version.

The next coop was designed as a tractor with skids. I had other visions of using it as a mobile milking parlor for goats so the design wasn't optimized exclusively for chickens. I built a 10ft x 12 ft frame from wood with silage tarp cover, and made two plywood skids for each side. These skids had a 45 degree angle on all sides to ride up over any obstacle ad where extremely heavy, perhaps 200 kg each. The plan was to use a winch to move this across the field. The area between the skids was open to the grass and I used 1 ft edpm skirts on the open end to keep the chickens in.

I never got chicken in this coop. The winch was barely able to move the skids and only when I had a barrel between the winch line and the land anchor to raise the pulling vector a bit above horizontal. At best is moved and ripped up the sod. While the calculated ground pressure wasn't too high, the rigid skids would only contact the rough ground in a few places so moving it was always shearing off the high spots.

I rebuilt this coop with 10 inch wheels for a movers dolly instead of the skids. Two wheels on each corner for 8 wheels total. I expanded the edpm skits around all the edges, and added electric wire whiskers hanging down on the inside around all the edpm skirts so the chickens would not try to go underneath. This was an unfounded fear, though the whiskers did work, the chickens were not really motivated to escape once habituated to the coop. I eventually removed the power to the whiskers as they did occasionally short. I also ran a length of electric fence wire around the external perimeter. I moved the coop with a winch as I was only barely able to lift one side. I used a lead out wire from the electric fence system to keep this coop in an unfenced field. The good:

1. It did not flip in high winds, no special precautions needed
2. It kept the chickens in and protected them from predators
3. It gave them fresh grass daily
4. Moving daily avoided all rat trouble, even though the hens left piles of grain behind them from overusing the peck activated feeder.

The bad:

1. Moving took too long with the winch. Turing around at the end of the field was almost impossible.

2. The wheels often got stuck in holes, on grass hills, brush stumps, basically on everything.

The next built coop was designed from the beginning for commercial production for 25-30 hens. I have a detailed CAD design attached, but the main difference was a 12 f x 6 ft house with two car wheels in the rear. I made wood block adapters so I could mount standard 5 bold steel rims to 5/8 steel rod axle. No bearings were needed. Two big wheels in the rear allowed me to lift the front by hand and walk backwards until the coop was entirely on fresh ground. A 6inch edpm skirt and electric wires inside and out kept the chickens in and predators out. The good:

1. It did not flip in high winds, but it does need to be set alongside a simmilar coop.

2. It kept the chickens in and protected them from predators

3. It gave them fresh grass daily

4. Moving daily avoided all rat trouble.

5. Nipple waterer needed only filling every 1-2 days with 20 liters for 25 hens.

6. head hole feed eliminated wasted feed

7. Easy to move, about 3 min and most of that is dealing with the electric lead out wire. Note that you do need to be able to deadlift at least 150 lbs to move it, which means my kids can't move it for me.

The bad:

1. Hard to move in the snow. If parked in the same spot because of too much snow for many days, rats can come in and steal feed, maybe eggs.

2.5 2025 jan as built

The current best chicken tractor is documented in these photos, and in the online CAD file `https://cad.onshape.com/documents/deba1f2c31d72fb79809290a/w/d69909f7fc1eea631c9f998c/e/a94a8dee5d359ccdf87478e9?renderMode=0&uiState=678e8795174af2356da8acb7` and the file is included in the git archive as a parasolid.

Figure 1: Inside chicken tractor 16 jan 2025

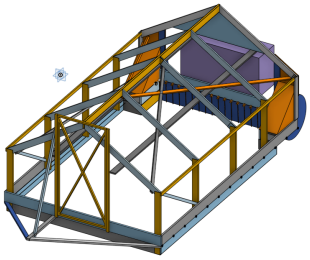

Figure 2: CAD design for chicken tractor, as built jan 2025

Figure 3: Front of chicken tractor, in heavy snow. Note pull bar

Figure 4: Inside chicken tractor, water detail. Open pans of water are best for below zero temperatures as they are easy to knock out when frozen.

Figure 5: Inside chicken tractor, electric fence line detail with edpm skirt on the the edges

Figure 6: Inside the rear of the chicken tractor, the skirt is 30 cm high so that it clears any larger obstacle in the middle of the tractor's path. The front is lifted while moving so that's not such a problem. The wires are 3mm diameter galvanized electric fence wire wrapped into a a spring shape, at 4 inch spacing. These are hot and prevent the chickens from trying to go under the rear flap.

Figure 7: Chicken tractor, rear outside. The spool of electric fence wire is suboptimal, a better solution must exist as this often becomes tangled.

Figure 8: Chicken tractor with hole feeder. The chicken tractor was recently moved onto snowy ground in this picture.

Figure 9: Inside the winch pulled chicken tractor. Here it has been parked for the winter and litter used.

Figure 10: Remaining frame from my first coop. Note that the wood frame is very thin to keep down weight but never had any problem with snow load. The silage tarp cover was slavaged for other projects.

3 Common problems

- Lock new chickens in coop for 3 days before letting them range, otherwise they may fly away, and at least will not have a homing at night instinct.
- Slat floors built with wood will often still require scraping so line up the slats so that scraping is parallel to the slat direction. Also in freezing weather manure will feeze to the slat instead of falling through.
- Rats are a serious problem. They eat feed and eggs and there doesn't seem to be a good way to eliminate them. I have a barn cat nearby and the rats will still dig tunnels under the coop. The best way I have found to stop the rats is moving the coop everyday. In winter this is hard. I also tried making a winter barrier with a 30 cm high electric fence. This had a length of 6 mil poly sealed to the ground with a perimeter of gravel. Then 3 electric lines were run on the outside of the poly, supported every 4 ft with a wood post. This worked mostly, but was not 100 percent rat proof. A stationary coop likely needs steel sides that extend 15 cm below ground level.
- Electric fence nets are difficult to use without tangling, and tangling is worse on pasture that has been recently cleared. Brush stumps and small bushes make the fencing a lot slower.
- Snow and mud make coops and tractors hard to move.

- The wind can easily flip most mobile coops. This is climate dependent of course, but make sure your coop can handle even the windiest day.
- If a chicken gets out, and can't be caught immediately, put some grain out at the door of the coop and the other chickens inside with attract them back. Then you might be able to catch the escapee in the evening. Most chickens have very poor endurance so try to chase them in large circles without stopping and they we become tired and easier to catch.

4 Winter

What to do with pastured chickens in the winter is in my mind an unsolved problem. I currently have one group of hens in a stationary coop with pine shaving litter for the winter, and another group in a tractor that I move when I can and let sit when there is too much snow. Feed consumption is also up to 1.5 times higher in the winter in an unheated coop.

The other option to consider is keeping the hens in a heated greenhouse/barn. If the farm has an insulated brooder barn for chicks that could work in the winter for the hens. Likewise a greenhouse could work as long as there were controls for avoiding too high of temperatures on sunny days. Ventilation is also important in both of these options. The profitability here depends on if the cost of feed is greater or less than the cost of a heated structure.

5 Cost breakdown

This section refers to the included spreadsheet. The real key to profitability is to reduce feed costs and labor time. Since the poultry maybe far out in the field as they are moved around, making sure that everything can be done in one visit per day is best. Bring food, water, light, collect eggs, move tractor coop all at once.

6 Egg washing

I wash eggs by hand. They also need to by dried before putting into cartons or they can stick and then break when the customer tries to remove them. An egg washing machine would be nice, but it would have to be quite cheap. `https://thelittleeggscrubber.com/` looks interesting but still kind of expensive, esp in CAD.

7 Marketing

I have been using the cooler and honour system. I have a locked money box where people can insert bill and coins, I also have posted information for e-transfer. E-transfer is not super popular but it is used occasionally. A cooler with ice works fine in the summer; in below-zero weather, I include a 4l jug of 20c water in the beginning of the day and this seems to prevent the eggs from freezing. I have a roadside stand in a rural but reasonably high traffic area. Most customers buy 1-2 dozen at a time. I have a few customers that buy 4-8 dozen eggs at a time, albeit infrequently. Competition from hobby farm egg sellers is minimal in the winter because hobby farmers typically do not supply supplemental lighting in the winter, and thus have very few eggs. Snow and poor weather does seem to mean fewer people stopping to buy eggs. Most customers are good about returning cardboard egg cartons for reuse, I've never had to buy cartons.

Marketing in the summer may become more difficult with competition from hobby egg sellers. A membership or subscription system for this would make sales more consistent but I think that would have to be combined with vegetable or other product sales to make it worthwhile for consumers.

I also incubate some eggs and sell balut to Asian markets. Both Vietnamese and Filipinos enjoy balut, though duck balut is more sought after. But this is a topic for another project.

8 Future projects

While I am reasonably satisfied with my current system, there is lots of room for improvement. To save time, I would like a better lighting system with a solar lamp. I will probably have to build it myself to get the right photoperiod for chickens. The lead out reel for the electric fence wire could be better, quicker to roll in and auto lead out. The feeder could have a treadle activated door to protect against rats, and be large enough for a full 20kg bag of grain.

To lower grain costs, grain could be planted in the field and then at least in the fall the tractor could allow for graze out. I also want to look into keeping them in a greenhouse in the winter since the temperature and humidity controls would already be in place for keeping the environment sutible for plants.

References

[1] A. Al-Saffar and S. Rose, "Ambient temperature and the egg laying characteristics of laying fowl," *World's Poultry Science Journal*, vol. 58, no. 3, pp. 317–331, 2002.

[2] B. F. R. E. P. Association. (2025) Greener eggs and ham, the benefits of pasture-raised swine, poultry, and egg production. [Online]. Available: https://www.bfrepa.co.uk/media-centre/stocking-density

[3] A. Australia. (2025) What does free-range really mean? [Online]. Available: https://animalsaustralia.org/our-work/factory-farming/what-does-free-range-really-mean/

[4] V. Berton and D. Mudd. (2012) Profitable poultry: Raising birds on pasture. [Online]. Available: https://www.sare.org/wp-content/uploads/Profitable-Poultry.pdf

[5] K. Clancy. (2012) Greener eggs and ham, the benefits of pasture-raised swine, poultry, and egg production. [Online]. Available: https://www.ucsusa.org/sites/default/files/2019-09/greener-eggs-and-ham.pdf

[6] F. Equipment. (2025) Featherman equipment prairie schooner 20 x 40. [Online]. Available: https://www.feathermanequipment.com/shop/prairie-schooners/20-x-40-schooner/?srsltid=AfmBOoql0JXjsQzLooyUkqhEK5iWQOZxNJ-Z1lCuORN54YDG7ZdIlbt9

[7] H. Karsten, P. Patterson, R. Stout, and G. Crews, "Vitamins a, e and fatty acid composition of the eggs of caged hens and pastured hens," *Renewable Agriculture and Food Systems*, vol. 25, no. 1, pp. 45–54, 2010.

[8] P. Lewis, G. Perry, and T. Morris, "Effect of size and timing of photoperiod increase on age at first egg and subsequent performance of two breeds of laying hen," *British poultry science*, vol. 38, no. 2, pp. 142–150, 1997.

[9] Y. Li, V. Arulnathan, M. Heidari, and N. Pelletier, "Design considerations for net zero energy buildings for intensive, confined poultry production: A review of current insights, knowledge gaps, and future directions," *Renewable and Sustainable Energy Reviews*, vol. 154, p. 111874, 2022.

[10] H. Ota, *Houses and Equipment for Laying Hens, for Loose Housing on Litter*. US Department of Agriculture, 1956, no. 728.