Indoor Tomato Production

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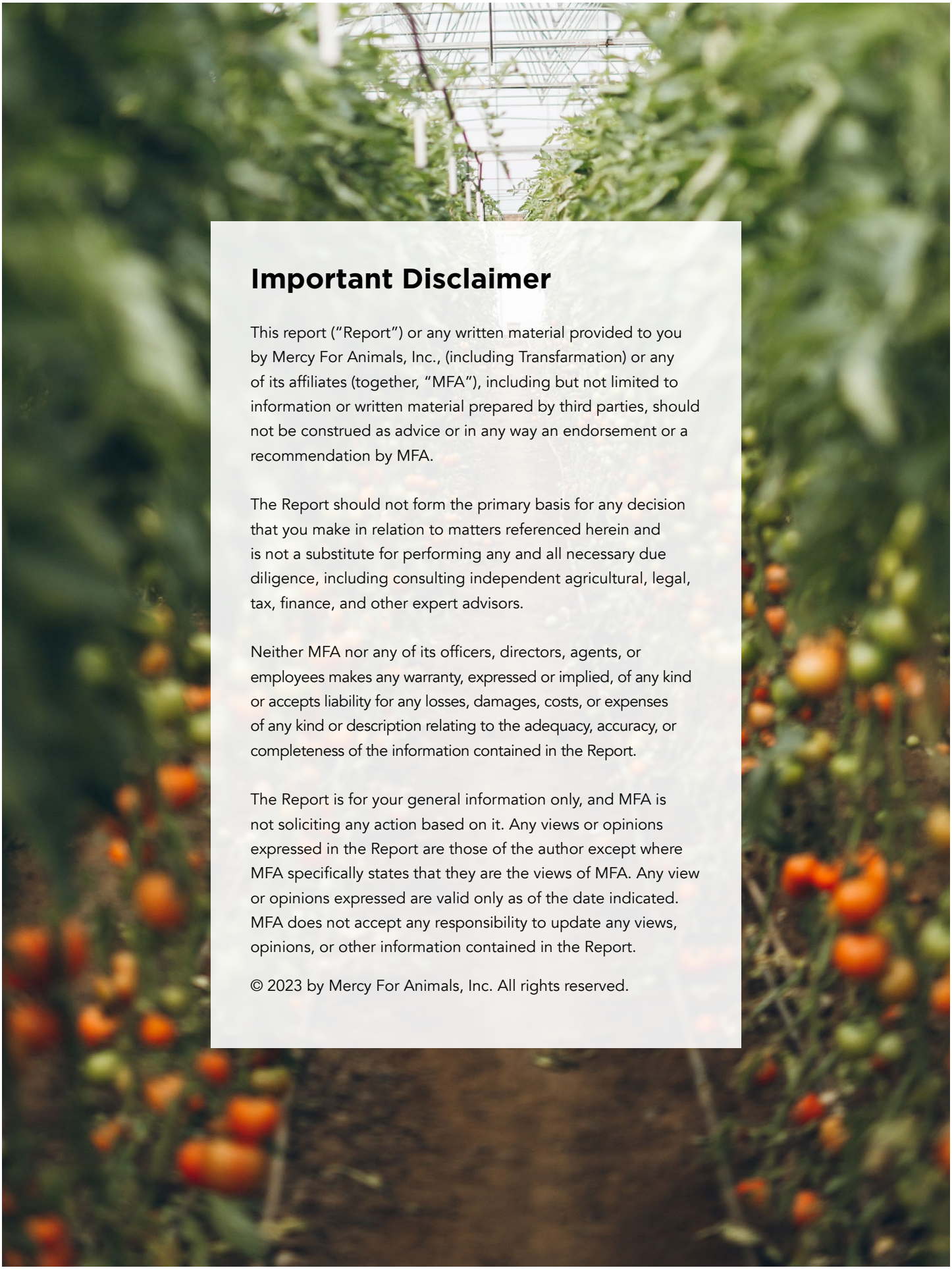

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Introduction

Fresh tomatoes are the second-most-popular fresh vegetable on Americans' plates, behind only potatoes.[1] In response to consumer demand for year-round fresh tomatoes, indoor tomato production has increased in recent years. Growing indoor tomatoes is complicated, with significant labor and management requirements to ensure a successful crop.[2] The following sections detail the market for fresh tomatoes nationwide, as well as typical indoor production practices, and provide an enterprise budget for producing conventional greenhouse tomatoes.

Market

- Indoor, climate-controlled agricultural production is termed "protected cultivation," which refers to the use of technology to extend a crop's growing season and yield.[3] In 2019, all 50 U.S. states produced tomatoes.[4] Nationwide, 52.6 million square feet of tomatoes were produced under protected cultivation conditions.[5]
- California leads domestic indoor tomato production, accounting for 19% (or 10.1 million square feet) of total U.S. production in 2019. Texas is the second-largest indoor tomato producer, with 10% (or 5.1 million square feet) of total U.S. production in 2019.[6]
- Tomato-producing greenhouses are highly concentrated in other states not traditionally market leaders in field-grown tomato production, including Nebraska and Minnesota.[7]
- Conventional fresh market tomatoes retailed for an average $1.69 per pound in 2021, ranging from $1.10 to $3.51 per pound according to variety.[8]
- The markup from farmer price to retail ranged from 130% to 384% in 2018.[9]
- The United States has a significant net fresh-tomato trade deficit, importing an average 3.2 billion pounds of fresh tomatoes and exporting just 121 million pounds.[10]
- Fresh tomato consumption is on the rise in America. Although food consumption is not measured directly, per capita availability data is often used as a representative metric for per capita consumption. Since 1970, fresh tomato availability has increased almost 60%, from 12.2 pounds per person to 19.3 pounds per person annually.[11] The 10-year normalized average per capita availability of fresh tomatoes (2011–2020) was 20.3 pounds per person.[12]
- Production from the greenhouse modeled in this analysis—16,000 square feet of a converted poultry house—would probably meet annual consumption demands for about 5,600 people.

Production Practices

Greenhouse tomatoes can be produced in soil, which is similar to outdoor tomato production, or in a soilless system referred to as "hydroponic," where tomatoes grow in raised beds in substrates such as rockwool, coco fiber, perlite, or peat, and the root system receives fertilizers through a water solution.[13] Large-scale U.S. growers (with greenhouses greater than one acre) use automatic climate control and hydroponic growing systems. These systems, along with indeterminate varieties, enable longer production seasons with 15 times the yield per area than is possible in field agriculture.[14] Greenhouse producers also see a much higher percentage of marketable fruit (at least 90% of total yield) than field producers (about 50%).[15]

Production cycles vary according to the sophistication of the technology used and the location of the greenhouse. Indoor producers in northern states typically plant in the winter and harvest in spring through fall.[16] Southern states have more sunshine in the winter, so growers typically plant in summer and harvest

[1] Sarah Baskins, Jennifer K. Bond, and Travis Minor, *Unpacking the Growth in Per Capita Availability of Fresh Market Tomatoes* (Washington, DC: USDA Environmental Research Service, 2019), 1, https://www.ers.usda.gov/webdocs/outlooks/92442/vgs-19c-01.pdf?v=3940.6.

[2] Cheryl Kaiser and Matt Ernst, *Greenhouse Tomatoes* (Lexington: University of Kentucky College of Agriculture, Food and Environment, 2018), 1, https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/ghtomatoes.pdf.

[3] Amit Kumar, Sachin Tyagi, and Neeraj Kumar, "Protected Cultivation of Vegetable Crops," *Dimensions of Agricultural Science* (November 2017): 61–67, https://www.researchgate.net/publication/321300522_Protected_Cultivation_of_Vegetable_Crops.

[4] "Quick Stats," USDA National Agricultural Statistics Services, accessed 2022, https://quickstats.nass.usda.gov/#3FD5E2C4-3BD5-%20322E-952E-BB350D7C7760.

[5] "Quick Stats."

[6] "Quick Stats."

[7] Baskins, Bond, and Minor, *Unpacking the Growth in Per Capita Availability of Fresh Market Tomatoes*, 5.

[8] "Quick Stats."

[9] "Producer Price Index," Western Growers, accessed 2022, http://www.producepriceindex.com/.

[10] Wilma V. Davis and Gary Lucier, *Vegetables and Pulses Outlook: November 2021* (Washington, DC: USDA Economic Research Service, 2021), 12, table 4, https://www.ers.usda.gov/webdocs/outlooks/102665/vgs-367.pdf?v=5063.3.

[11] *Sep 15, 2022: Vegetables and Pulses Yearbook: Dataset* (Washington, DC: USDA Economics, Statistics and Market Information System, 2022), Google spreadsheet, sheet 1, https://usda.library.cornell.edu/concern/publications/d791sg170?locale=en#release-items.

[12] *Vegetables and Pulses Yearbook*, sheet 1.

[13] Alvin D. Rutledge, *Commercial Greenhouse Tomato Production* (Knoxville: University of Tennessee Agricultural Extension Service, n.d.), 5, https://extension.tennessee.edu/publications/Documents/pb1609.pdf.

[14] Paul Selina and Michael E. Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline* (Washington, DC: USDA National Institute of Food and Agriculture, 2002), 1, https://ipmdata.ipmcenters.org/documents/timelines/USgreenhousetomato.PDF.

[15] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 1.

[16] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 1.

in fall through early the following summer.[17] Some growers harvest tomatoes year-round where the local climate is suitable or supplementary lighting or cooling systems are installed[18] (neither lighting nor cooling is considered below).

This budget focuses on indoor hydroponic tomato production with two planting cycles annually, which allows for harvest for nearly the entire year.[19] Specific operating costs and production practices will depend on the tomato variety, means of climate control, access to light, and nutrient systems. This production budget relies on representative assumptions to inform the planning for production of conventional tomatoes in a greenhouse environment. The following section details the steps and expected costs and returns of tomato production in 16,000 square feet of space. This assumption is for one former poultry barn (50' x 400') with 4,000 square feet set aside for packing, storage, and associated utilities.

Enterprise Budget

Indoor tomatoes are demanding to produce, with significant labor and management requirements. Table 1 below presents the representative tomato enterprise budget. The budget is a generalized reference and should be adapted to the specifics of any production operation.

YIELDS AND PRICES RECEIVED

Greenhouse growers often command higher prices by offering out-of-season fresh produce, although expanding out-of-season international production puts increasing pressure on U.S. greenhouse tomato prices.[20] The weighted average retail price of conventional greenhouse tomatoes from more than 1,900 stores nationwide was $1.86 per pound in February 2022.[21] With an average wholesale to retail tomato markup of 56%,[22] the wholesale pricing presented in the enterprise budget modeled here is $1.19 per pound. Of note, certified-organic hydroponic production could fetch even higher prices. For example, certified organic tomatoes sold at an average retail price of $3.52 per pound in 2020,[23] which represents a wholesale price of $2.26 per pound.

This enterprise budget uses annual greenhouse tomato production yields of six to eight pounds per square foot, which are consistent with published estimates.[24] The 16,000-square-foot production area modeled in this budget is expected to yield a total of roughly 114,000 pounds of tomatoes.

LABOR

Indoor tomato cultivation requires significant labor inputs. Labor requirements are heavily concentrated in the planting and harvesting phases. In similar tomato enterprise budgets, labor accounts for roughly 40%–60% of total production expenses.[25] This includes labor requirements for seeding, transplanting, pruning and harvesting, management, maintenance, marketing, and delivery of the crop. In total, we estimate these tasks will require nearly 4,400 hours over one year for 16,000 square feet of greenhouse. A labor rate of $17.58 per hour[26] amounts to labor costs of over $77,000 annually. This represents about half the total variable costs and is consistent with published tomato enterprise budgets.

[17] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 1.
[18] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 1.
[19] This could be accomplished by interplanting crops at different intervals.
[20] Roberta Cook and Linda Calvin, *Greenhouse Tomatoes Change the Dynamics of the North American Fresh Tomato Industry* (Washington, DC: USDA Economic Research Service, n.d.), 2–7, https://www.ers.usda.gov/webdocs/publications/45465/15301_err2b_1_.pdf?v=0.
[21] "Specialty Crops: Market News," USDA Agricultural Marketing Service, accessed 2022, https://www.marketnews.usda.gov/mnp/fv-report-retail?portal=fv&category=retail&type=retail&region=NATIONAL&organic=ALL&navClass=&commodity=TOMATOES.
[22] Ilanit Hayut, "Agrexco: Supermarket Markups on Fruits and Vegetables Are as High as 74%," *Globes*, February 20, 2014, https://en.globes.co.il/en/article-retailers-average-vegetables-markup-417-1000918746.
[23] "Organic Tomatoes Brought In More Than $233 Million in Sales in 2019," the Packer, February 2, 2021.
[24] Elizabeth Canales Medina and Richard Snyder, *Greenhouse Tomato Budgets for Mississippi* (Lafayette County, MS: Mississippi State University Extension, 2020), 11, table 7, http://extension.msstate.edu/sites/default/files/publications/publications/P2766.pdf; John Smith et al., *A Profitability and Cash Flow Analysis of Typical Greenhouse Production in North Florida Using Tomato as an Example* (n.p.: WeatherReport.com, 2015), 3, http://weatherport.com/wp-content/uploads/2015/05/cashflowanalysis.pdf.
[25] Smith et al., *A Profitability and Cash Flow Analysis of Typical Greenhouse Production in North Florida Using Tomato as an Example*, 3; Medina and Snyder, Greenhouse Tomato Budgets for Mississippi, 5, table 3.
[26] U.S. Bureau of Labor Statistics, *Employment Cost Index* (Washington, DC: U.S. Bureau of Labor Statistics, 2022), table 11, https://www.bls.gov/news.release/eci.t11.htm.

The table below provides the major labor operations and their frequency.

TABLE 1. TYPICAL LABOR OPERATIONS

Operation	Frequency	Description
Crop training*	Weekly or biweekly	Training plant to support strings Removal of side shoots (suckers) Handling new growth at top of plant Removing excess flowers on clusters
Leaf removal*	Weekly	Trimming 2–3 leaves at bottom of vine to expose clusters
Harvest*	2–4 times per week	Picking ripening fruit and placing in crates
Clean-out	Yearly	Removing plants Removing media Disinfecting with bleach solution
Preparation	Yearly	Laying new plastic floor Locating bags of growing substrate Placing irrigation drippers at each hole
Planting	Yearly or semiannually	Placing plants in growing medium Tying plants to support string
Propagation / interplanting		If plants are grown on-site, the process is the same as above but with smaller cells. Plants can be interplanted underneath mature plants to get 2 crop cycles per year.

*These tasks amount to around 75% of annual labor inputs for a tomato greenhouse.

Source: Paul Selina and Michael E. Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline* (Washington, DC: USDA National Institute of Food and Agriculture, 2002), 4–5, table 1, https://ipmdata.ipmcenters.org/documents/timelines/USgreenhousetomato.PDF.

INPUTS

Tomatoes are a warm-season crop and thus very sensitive to light and temperature.[27] Tomatoes grow best when night temperatures are no lower than 60°F and no higher than 90°F.[28] Tomato fruit is heavy, so plants require support in the form of hooks, clips, and twine to grow.[29]

Specific adverse environmental conditions can cause physiological problems for tomato plants. These include blossom-end rot, a calcium deficiency at the blossom end of the fruit, which can be ameliorated with evenly supplied moisture during plant growth and possibly application of calcium spray; blossom drop, a reduction in yield that occurs when night temperatures are too high; and fruit cracking, which can be prevented with evenly supplied moisture and avoidance of fertilization spikes. Catfacing and puffiness are difficult to avoid except by ensuring proper planting timing. Graywall and blotchy ripening can be caused by bacteria and managed with proper fertilization.[30] Fertilizer, calcium, and fungicide needs will be specific to production. This budget models a representative regime from The Ohio State University Extension for hydroponic tomato production.[31]

This budget models inputs for beneficial insects, such as lacewings, *Encarsia formosa*, *Aphidius colemani*, and bees. These beneficials, along with screens and location, are preferred to pesticides as a means of pest control in large-scale greenhouses.[32] Fertilizers for the tomato operation include a blended mix and calcium nitrate $Ca(NO_3)_2$. The budget also models fungicides and pesticides, sanitizer, and substrate materials.

[27] Robert G. Anderson, *Greenhouse Tomato Production Practices* (Lexington: University of Kentucky, College of Agriculture, Cooperative Extensions, 2020), 1, https://www.uky.edu/hort/sites/www.uky.edu.hort/files/documents/greenhousetomatoes.pdf.

[28] Anderson, *Greenhouse Tomato Production Practices*, 2.

[29] Anderson, *Greenhouse Tomato Production Practices*, 3.

[30] University of Kentucky Center for Crop Diversification, *Tomatoes, Staked: Fresh Market, Trickle Irrigated* (Lexington: University of Kentucky CCD, 2017), https://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/largescaletomatobudget.pdf.

[31] The Ohio State University, "Hydroponic Crop Program: Economic Budgets," The Ohio State University, accessed 2022, https://u.osu.edu/greenhouse/hydroponic-crop-program-economic-budgets/.

[32] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 8.

The greenhouse tomato varieties used commercially in the United States are produced by Dutch or Israeli seed companies. While most growers buy transplants from specialist propagators, seedlings can be grown in a separate part of the greenhouse (in half-inch plugs) and transplanted to four-inch cubes around two weeks after planting. To allow for larger plants, the cubes can be placed 12 inches apart around three weeks after initial planting.[33]

PACKAGING

Retail tomato markets require one- or two-pound produce containers stacked in cardboard boxes (10 pounds to a box) and stickers for branding.

UTILITIES

The utility requirements of a greenhouse will include fuel for heating, electricity for fans, water, sewer, and online or telecommunication. This budget assumes that natural gas heating will require 2,180 cubic feet at $9.52 per 1,000 cubic feet. It also anticipates electricity requirements of 50,000 kilowatt hours per year at $0.12 per kilowatt hour.[34] Utilities represent around 15% of total operating costs for the greenhouse.

OTHER OPERATING COSTS

Miscellaneous costs include laboratory fees (e.g., for leachate, tissue, and nutrient solution analyses) estimated at $720 per year, office supplies ($300), postage, and marketing materials ($300). In total, this category is expected to represent $1,320 per year in costs, or 1% of variable costs.

CASH OVERHEAD

Property taxes for the grow operation will be specific to the location but are modeled here at $250 per month, or $3,000 per year. Some states may impose income or other taxes in addition to property taxes, but we do not model these here.

This analysis does not assume any land costs; thus the identified profit should be considered a return-on-land estimate. General liability insurance is modeled at $70 per month, and property insurance is estimated at $200 per month. Therefore total insurance costs are estimated at $3,240 annually.

CAPITAL COSTS AND NON-CASH OVERHEAD

The capital cost of the greenhouse conversion from the existing poultry house is estimated at $5.47 per square foot, or $87,520 for the structure (16,000 square feet of production area).[35] In addition, this analysis models Carolina Greenhouses' Dutch bucket system as the hydroponic production system, estimated at $35,760.[36] Environmental controls and additional growing equipment, estimated at $24,540, will also be needed for the greenhouse operation. We calculated this figure from a list of operational requirements developed by The Ohio State University Extension and indexed cost factors to 2022 dollar values:

- Backup generator: $5,200
- Cooling system: $2,400
- Computer for environmental controls: $3,200
- Heating system: $2,600
- Sprayer: $200
- CO2 generator: $480
- Cooler: $2,000
- Fertilizer mixing pump: $60
- Feeding system: $6,400
- Meters, monitors, sensors, and scale: $2,000

Thus, the estimated total capital expenditure of converting a poultry barn into a functioning greenhouse for hydroponic production is **$147,820**. This enterprise budget further assumes that the owner could finance the conversion through existing programs offered by the Small Business Administration, the United States Department of Agriculture, and possibly other lenders. This budget models the debt service terms of the SBA 504 program—10% equity requirement (90% financed), or $14,782. Further, the budget considers 10- and 20-year notes, at 6.5% and 6% interest, respectively, as of December 2022.[37]

NET PROFIT

Based on the assumptions outlined above, including projected yield, the breakeven price for tomatoes from a 16,000-square-foot greenhouse production area is around $1.51 per pound. This is comparable to the average U.S. retail price of conventional tomatoes in February 2022 and much higher than the average farm price for U.S. greenhouse tomatoes ($1.19 per pound).

[33] Selina and Bledsoe, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*, 5.

[34] "Electricity Rates," Electric Choice, accessed 2022, https://www.electricchoice.com.

[35] Quotes for conversion of a chicken house to crop production range from $3 to $8 per square foot according to the type of material used to cover the structure. The $5.47 estimate represents the midpoint between the double-layered film ($4.23) and corrugated polycarbonate ($6.23). Conversion costs include fans, groundcover, ventilation control, and shade cloth, along with labor and material costs. *Sources:* North Carolina Greenhouses, *Material and Labor Quotes* (prepared for Mercy For Animals); Virginia Tech College of Agriculture, *Converting a Chicken House into a Greenhouse* (prepared for Mercy For Animals).

[36] The quote is for 100' of greenhouse for $11,175; this budget assumes 320' of greenhouse to be used in crop production, or $35,760 total. *Source*: North Carolina Greenhouses, *Material and Labor Quotes.*

[37] "504 Rate History," CDC Loans, accessed 2022, https://cdcloans.com/sba-504-rates/.

This illustrates that (1) producers with greater than one acre under glass have captured economies of scale whereby they can enter the value chain at a much lower price point and still be profitable and (2) certified organic or another distinctive product characteristic may be necessary to provide a price premium that would enable a profit return at the scale of a single poultry house. The enterprise budget below assumes a price point of $2 per pound.

TABLE 2. REPRESENTATIVE GREENHOUSE TOMATO ENTERPRISE BUDGET

Unit	Unit	Quantity	Price	Value
Gross returns	**Pound**	**114,000**	**$2.00**	**$228,000**
Variable costs:				
Lacewing	packages	38	$36	$1,368
Encarsia formosa	packages	18	$27	$486
Aphidius colemani	packages	6	$53	$318
Fertilizer – mix	pounds	2,480	$2.10	$5,208
Fertilizer – $Ca(NO_3)_2$	pounds	2,480	$0.40	$992
Fungicide / Pesticide	gallons	14	$20	$280
Sanitizer	gallons	10	$24	$240
Rockwool cubes (1 in)	cases	2	$375	$750
Rockwool slabs	bags	168	$85	$14,280
Seed	packages	14	$115	$1,610
Hooks, twine, and clips	total			$660
Labor	hrs	4,398	$17.58	$77,317
Packaging – clamshells	cases	380	$45	$17,100
Packaging – boxes	box	11,400	$0.76	$8,664
Labels	roll	96	$30.00	$2,880
Natural gas	1,000 cu ft	2,180	$9.52	$20,754
Electricity	KwH	50,000	$0.12	$6,000
Miscellaneous				$7,560
Insurance				$3,240
Property tax				$3,000
Total variable cost				**$172,706**
Operating income				**$55,294**

Debt obligation (20 years, 6% interest)	*$11,599*
Debt service coverage ratio	**4.77**

Debt obligation (10 years, 6.5% interest)	*$18,506*
Debt service coverage ratio	**2.99**

The estimated operating profit of $55,294 from the converted poultry house represents a profit of $0.49 per pound of tomatoes yielded from greenhouse production. Debt service coverage ratio (DSCR) is a measurement of an operation's available cash flow to pay current debt obligations, calculated as net income divided by debt obligations (principal and interest payments). A DSCR of less than 1.0 poses potential solvency problems, while a ratio of at least 2.0 is generally considered very strong.

SENSITIVITY

A sensitivity analysis was undertaken to evaluate the impact of key assumptions on the net profit estimate for the enterprise in question. The key assumptions included are as follows:

- Yield (six to eight pounds per square foot)
- Price Received ($1.19 to $2.25 per pound)
- Labor Rate ($15 to $20 per hour)
- Clamshell Price ($40 to $50 per case)

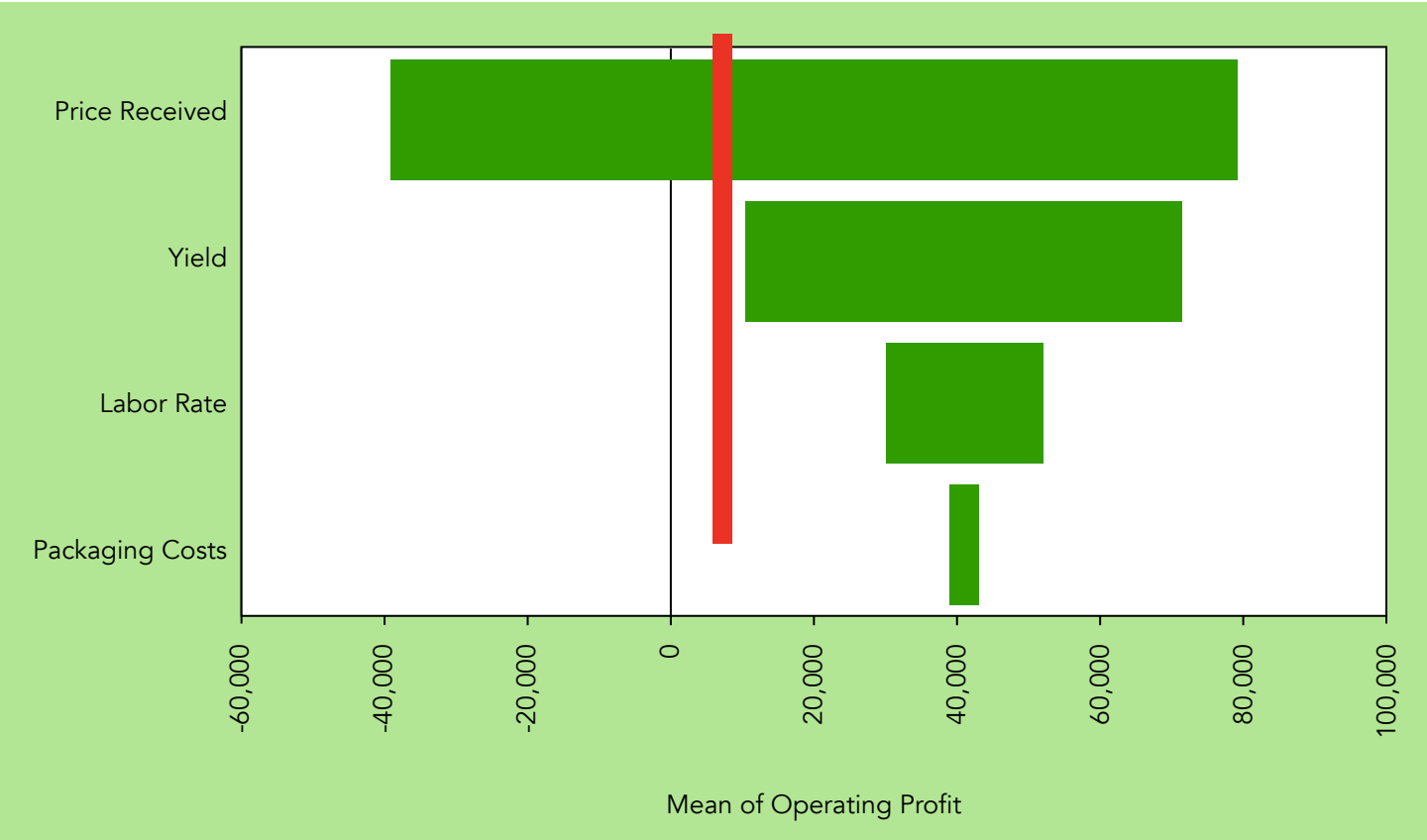

Figure 1. Bar chart revealing impact of key assumptions on net profit.

Price is the most sensitive variable of those considered in this model. As mentioned, at the scale modeled here, the published market prices for conventional greenhouse tomatoes are unlikely to generate a profit. Thus, we recommend that the producer consider organic certification or other differentiation strategy whereby a price point of at least $2 per pound could be achieved. The red line in figure 1 indicates the level at which the DSCR would fall below 1.0. This occurs only in the low ends of the price and yield ranges considered in the analysis.