



# Deep Winter Greenhouse Enterprise Analysis

**A STUDY OF THE COSTS AND BENEFITS OF OPERATING DEEP WINTER GREENHOUSES IN MINNESOTA AND WISCONSIN**

Authored by Ryan Pesch



Photo by Ryan Pesch

IN PARTNERSHIP WITH UNIVERSITY OF MINNESOTA'S DEPARTMENT OF HORTICULTURE AND REGIONAL SUSTAINABLE DEVELOPMENT PARTNERSHIPS



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**June, 2015**

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**A special thanks to all growers who participated in this research and shared information about their operations.**

**We hope this research helps existing growers improve their operations and assist prospective operators in planning reasonable winter greenhouse projects.**

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## EXECUTIVE SUMMARY

A University of Minnesota Extension investigation of seven deep winter greenhouse enterprises found that most are operating profitably, and growers are seeing a positive return on investment. Though winter greens such as baby kale, arugula, and Asian greens are becoming increasingly popular among customers and in grocery aisles, study participants report they market most of their products directly to customers rather than through wholesale market channels. Extension's research also shows study participants who marketed through winter Community Supported Agriculture (CSA) arrangements were more profitable than those who did not.

In this study, deep winter greenhouses cost an average of \$25,500 to construct, or an average of approximately \$60 per square foot of space. Although start-up costs are significant, study participants realized an overall return on investment (ROI) of 3%, ranging from -3.6% to 21.5%, with a median payback time of eight years. In terms of annual expenses and returns, variable costs such as propane, seeds, and soil mix range from \$440 to \$1,170 to produce a crop, or an average of \$4.10 per square foot of growing space. All but one participant experienced positive operating revenue for an average of \$1,717 per enterprise, or nearly \$7 per square foot of growing space.

An investigation of grocery stores found that all sell salad greens that can be grown in deep winter greenhouses, including baby kale, arugula, and mixes of lettuces and Asian greens. Two national brands, Earthbound and Taylor Farms, dominate the organic salad greens market, which may minimize market share for local growers, causing them to search for alternative ways of marketing their product.

Study findings suggest three success factors for operating a profitable winter greenhouse enterprise. Prospective and current operators should consider the following recommendations:

### **#1: Maximize use of space**

The two most profitable greenhouses in this study, with the highest return on investment, maximized their space for growing. Measured as a proportion of greenhouse space to growing space, utilization rates of 88 and 80 percent corresponded to ROIs of 22 and 17 percent, respectively. Operators achieved optimal space utilization by creating maximum growing space on the floor and using hanging trays to take full advantage of vertical space. Considering the relatively high cost of deep winter greenhouses, maximizing space is critical to developing profitable winter greenhouse enterprises.

### **#2: Pursue direct-to-consumer marketing channels**

In addition to maximizing space, successful winter greenhouse operators also sold product through a winter CSA arrangement. Just as with summer CSA arrangements, winter CSAs provide a mix of products directly to customers on a periodic basis. Operators provided members with winter greens grown in the deep winter greenhouse, and some supplemented greens with fall storage crops, such as potatoes, winter squash, and root crops. Of the study participants utilizing winter CSAs, all but one delivered or arranged weekly pick-up during a four to five month winter season; one arranged five large deliveries between November and March.

### **#3: Keep start-up costs as low as possible**

A promise of deep winter greenhouses is the ability to construct an efficient building with common building materials and straightforward construction methods. The materials, labor, and design

elements chosen, however, can have a significant impact on the final price tag. Higher-cost, customized options can push expenses for a greenhouse well past comparable, low-cost kit options. For example, one 12 by 24 foot greenhouse in the study was built for less than \$6,000, or \$20 per square foot, whereas another cost more than \$73,000. High depreciation expenses associated with expensive building materials and costly design features, such as solar thermal systems and wired automatic shutters, can be difficult to overcome to achieve high return on investment.

## **METHODOLOGY**

Detailed information was collected about start-up and operating costs, greenhouse dimensions, and labor inputs from seven deep winter greenhouse operators in Minnesota and Wisconsin. The scope of the study was limited to operations selling food produced in the greenhouse and using the Garden Goddess deep winter greenhouse design as outlined in *The Northlands Winter Greenhouse Manual* (polycarbonate-covered greenhouse of stick construction with a subterranean heat sink). Since its publication in 2009, *The Northlands Manual* has inspired many people to build winter greenhouses. A total of ten operating in Minnesota and Wisconsin were identified after investigation both online and through interviews with winter greenhouse operators, but only seven chose to participate in this study.

The current price of greens in grocery stores was also evaluated, since off-season greens are the primary product grown in deep winter greenhouses.

### **Data collection procedure**

During fall 2014, participants were recruited through phone calls, email, and a mailing. Participants received data collection spreadsheets to fill out regarding start-up and annual variable costs, as well as labor inputs. Individual financial records were used to complete the spreadsheets, and while many respondents had very accurate and precise records, participants estimated figures at times based on past production experience. Consequently, these assumptions may affect the precision of study findings.

All participants were individually interviewed over the phone to facilitate the collection of data. The collection of winter greens price data occurred during in-person price checks in January, February, and March 2015. Seven grocery stores were visited, and the prices of comparable greens products were subsequently recorded.

### **Calculations and comparisons**

Since the primary questions about deep winter greenhouse operations are about financial returns and payback, analysis is focused on annual return to operations and labor but with a special emphasis on return on investment and payback time. The operational costs and returns vary significantly, and only one greenhouse did not experience a positive net revenue.

## **DEEP WINTER GREENHOUSE ENTERPRISE FINDINGS**

The deep winter greenhouses that participated in this study varied significantly in their annual operating costs and returns, as well as start-up costs.

## About Deep Winter Greenhouse Structures and Operations

The operators that participated in this study built a range of deep winter greenhouse structures. Although based on the same original design outlined in *The Northlands Winter Greenhouse Manual* (<http://www.gardengoddessenterprises.com/>), sizes ranged from 288 square feet (12 x 24 feet) to 768 square feet (24 x 32 feet) and included the following design features:

- One greenhouse incorporated thermal solar panels and in-ground floor heat, in addition to a rock heat sink.
- Two greenhouses were built into hillsides instead of level ground.
- Three greenhouses used heat generated by wood boilers.
- Two greenhouses were free-standing structures while the others were attached to pre-existing buildings.

All of these design features affect construction cost, and potentially, the performance of the structures themselves (there is no specific data, however, to discern how individual design features have influenced heating costs or production, especially as each greenhouse faces distinct climatological conditions).

All deep winter greenhouse operations in this study were relatively new. The oldest facility was built in 2010, five were built in 2012, and the newest was built in December 2014, which belongs to the author of this report. Each greenhouse had a single person who handled nearly all of the daily chores of planting, watering, and harvesting with assistance from a spouse or other family member. All greenhouses were commercial in nature.

In terms of production, all greenhouse operators raised winter greens such as arugula, lettuces, and Asian greens and select roots crops like turnips and radishes. For greens production, operators took multiple cuttings of each planting. No study participants used chemical herbicides or pesticides, and all generally used only organic inputs for soil mix, such as blood and bone meal (although a few sourced exclusively organic seed). As a result, certified organic greens prices were collected during price checks because they were the most comparable product (see Section Winter Greens Grocery Price Documentation).

### Start-up costs

An investment in a deep winter greenhouse is significant. The average start-up cost among participants was \$25,502. Five of the seven ranged between \$16,533 - \$24,042 with two costing \$5,797 and \$73,035, respectively.

Start-up costs include building the greenhouse and preparing it for its first season. Individual expenses include lumber, polycarbonate sheets, and hardware, as well as excavation and foundation work. Additional costs include ground inputs for a heat sink (e.g., rock and sand); heating improvements (including a backup heat source or upgrades to heating systems); construction labor; and initial growing supplies (for example, trays and lumber to build raised beds).

The lion's share of start-up costs fall in the building materials category, accounting for 67% of total building costs, followed by ground work—including excavation and foundation work—and heating improvements. Most study participants did a majority or all of the construction themselves, which explains the relatively low cost of construction labor.

**Table 1: Total start-up costs for all greenhouses in study summed by category**

<b>Start-up cost category</b>	<b>Total cost for all participating</b>	<b>Percentage of total costs</b>
Building materials (polycarbonate panels, lumber, hardware)	\$111,887	63%
Ground work (Excavation, ground inputs, cement)	\$24,446	14%
Heating (back up heater, solar thermal, wood boiler improvements)	\$17,468	10%
Construction labor	\$12,330	7%
Electrical (fans, thermostats)	\$10,838	6%
Growing supplies (trays, gutter, lumber for beds, others)	\$1,545	1%
<b>Total</b>	<b>\$178,514</b>	<b>100%</b>

A helpful way to consider start-up costs is on a square foot basis. For this study, the total square footage of each greenhouse and growing space (total amount of space in hangers plus area planted on the ground) was collected.

The average and median cost per square foot of space was \$61 and \$47, respectively, ranging from \$20 per square foot to \$133 per square foot. As a point of comparison, a 14 x 24 foot twin-wall polycarbonate greenhouse kit (not installed and without the passive solar heat sink) from Farmtek costs \$14,750, or \$42 per square foot.

**Table 2: Start-up costs per greenhouse and per square foot of space and growing space**

	<i>Grnhse1</i>	<i>Grnhse2</i>	<i>Grnhse3</i>	<i>Grnhse4</i>	<i>Grnhse5</i>	<i>Grnhse6</i>	<i>Grnhse7</i>	<b>Average</b>	<b>Median</b>
<b>Start-up cost</b>	\$17,850	\$5,797	\$73,035	\$24,042	\$20,679	\$20,578	\$16,533	\$25,502	\$20,578
<b>Cost per sq. ft.</b>	\$34	\$20	\$172	\$47	\$72	\$27	\$55	\$61	\$47
<b>Cost per sq. ft. of growing space</b>	\$38	\$40	\$345	\$121	\$90	\$73	\$134	\$120	\$90

Looking solely at growing space, there was an average cost of \$120 per square foot and a median cost of \$90 per square foot. Growing space returned nearly an average of \$7 per square foot of operating revenue annually, calculated as gross sales minus variable expense (see Table 3).

### Product marketing

All deep winter greenhouses grew and marketed similar products, primarily winter greens and lettuces that do well in a cool environment. They also grew cole crops, Swiss chard, and root crops, such as radishes and turnips. Two operators supplemented CSA shares with storage crops including onions, roots, and winter squash; two only included crops grown in the winter greenhouse.

Gross revenue, or sales, for the greenhouses ranged from \$447 to \$5,527. Removing variable costs necessary to grow a crop (seed, soil mix, and fuel), it was found that all but one greenhouse had positive operating revenue (gross revenue minus variable costs). Converting revenue per greenhouse to operating revenue per square foot of space, participants took in an average of nearly \$7 per square foot, ranging from negative \$1.88 to positive \$17.34 (see Table 3).

A common way of presenting operating revenue is through a measure of gross margin. Calculated as operating revenue divided by gross revenue, gross margin is a percentage of gross sales an operator retains after taking out direct expenses to produce a crop. For example, one greenhouse kept 81 cents of every dollar it sold and therefore had a gross margin of 81%. Study participants ranged from a negative gross margin of 118% to positive 81% with average and median gross margins of 34 and 57 percent, respectively (see Table 3).

**Table 3: Gross Revenue and Operating Revenue\***

	<i>Grnhse1</i>	<i>Grnhse2</i>	<i>Grnhse3</i>	<i>Grnhse4</i>	<i>Grnhse5</i>	<i>Grnhse6</i>	<i>Grnhse7</i>	<b>Average</b>	<b>Median</b>
<b>Gross Revenue</b>	\$5,527	\$1,511	\$1,000	\$3,600	\$5,150	\$447	\$1,025	\$2,609	\$1,511
<b>CSA</b>	\$5,527	\$488		\$3,600	\$5,000				
<b>Direct Sales</b>		\$1,023	\$1,000		\$150	\$447	\$1,025		
<b>Operating Revenue</b>	\$4,491	\$688	\$220	\$2,580	\$3,984	\$(527)	\$582	\$1,717	\$688
<b>Operating Revenue per Sq Ft of Growing Space</b>	\$9.67	\$4.79	\$1.04	\$13.03	\$17.34	\$(1.88)	\$4.73	\$6.96	\$4.79
<b>Gross Margin</b>	81%	46%	22%	72%	77%	-118%	57%	34%	57%

\*Average for all the winter seasons in operation

It should be noted calculations were based on average gross revenue for all seasons in operation. This fact causes lower gross revenues since greenhouses that have been operating for multiple years had lower sales when they started than during the most recent growing season. Participants operating for multiple seasons reported better efficiency and winter crops now than when they first started.

### Operating Costs and Returns

All but one greenhouse experienced positive operating revenue (defined as gross revenue minus variable expenses, such as fuel, soil mix, and seeds). Setting aside the capital costs associated with building a greenhouse, these operations have realized an average gross margin of 34%, meaning operators kept 34 cents of profit for each dollar of revenue. Gross margins ranged from negative 118% to 81%; this variation is explained primarily through the difference in revenue, as variable costs were fairly consistent for most of the greenhouses (approximately \$1,000) with an average annual

variable cost of \$892. Those operating winter CSAs had three of the four highest gross margins, ranging between 54% and 81% (see Table 3). This difference in how product is marketed also translated to significant differences in profitability (see Financial Performance section).

**Table 4: Operating expenses\***

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Average	Median
<b>Annual variable expenses*</b>	\$1,036	\$823	\$780	\$1,020	\$1,166	\$974	\$443	\$892	\$974
<b>Seeds</b>	\$120	\$92	\$200	\$240	\$177	\$65	\$40	\$133	\$120
<b>Propane</b>	\$500	\$217	\$170	\$403	\$267	\$528	\$0	\$298	\$267
<b>Soil Mix</b>	\$276	\$340	\$300	\$57	\$72	\$28	\$321	\$199	\$276
<b>Marketing costs</b>	\$50	\$25	\$0	\$220	\$650	\$10	\$67	\$146	\$50
<b>Utilities</b>	\$90	\$150	\$30	\$100		\$165	\$15	\$92	\$95
<b>Other</b>			\$80			\$179		\$130	\$130

\*Average for all the winter seasons in operation

The largest variable expense is propane, followed by soil mix, marketing, and seed costs. The vast majority of marketing costs – costs incurred once a crop is raised – involves delivery expenses, as some operators deliver their product to buyers. Considering the greenhouses generally operate October through March, fuel costs were relatively low; the average fuel cost was \$298 annually. Two operations had no fuel costs during the 2014-15 season, using heat exclusively from wood boilers.

### Financial Performance

The primary measure of financial performance for any enterprise is net revenue, calculated as gross revenue minus both capital and operating (variable) expenses. In this instance, the annual depreciation expense (capital costs) and annual operating expenses were subtracted, such as seed and propane (operating costs) from gross (see Table 5).

Results suggest a significant split in profitability between operators who marketed their products through CSAs and those who sold a la carte, whether through direct sales to households or to schools or restaurants. While the CSA operators all experienced positive net revenue (which includes variable expenses and depreciation) and return on investment (ROI), the others did not. The ability of CSA operators to fetch a higher price or sell all greenhouse products may explain the varying performance of these enterprises. In the case of greenhouses six and seven, high capital costs did not cause negative net revenue but rather relatively low gross revenue. Greenhouse three, in contrast, had a high depreciation expense to overcome in order to break even.

**Table 5: Net Revenue, capital costs (depreciation expense), and operating costs (variable expenses)**

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Average	Median
<b>Net Revenue</b>	\$3,837	\$516	\$(2,641)	\$1,678	\$3,217	\$(1,290)	\$(19)	\$757	\$516
<b>Capital costs</b>	\$654	\$172	\$2,861	\$902	\$767	\$763	\$601	\$960	\$763
<b>Operating costs</b>	\$1,036	\$823	\$780	\$1,020	\$1,166	\$974	\$443	\$892	\$974

### Payback and Return on Investment

One of the most common questions of prospective winter greenhouse operators is the return on investment or payback time.

Calculated as net revenue divided by start-up costs, return on investment (ROI) ranges from 21.5% down to -6.3% with an overall ROI for all seven greenhouses of 3% (see Table 6). Instead of an average, an overall ROI was calculated by dividing total net revenue by total start-up costs for all greenhouses.

In comparison, payback time does not account for capital costs or depreciation but instead is calculated as start-up costs divided by operating revenue. Calculated this way, payback time ranges from as few as four years to as many as 332 years, with average and median payback times of 11 and eight years respectively. The average and median payback times were calculated with only five of the seven operations, as two emerged as outliers with an undue influence on this calculation. Greenhouse three experienced extremely high start-up costs related to the financial means of the builders that are unlikely to represent the financial position of most potential greenhouse builders. The operators of greenhouse six had unusually low gross revenue since they had not yet added hanging planters and thereby limited their revenue. And, in fact, their negative operating revenue would have resulted in a negative payback time (see Table 6).

**Table 6: Return on Investment (ROI) and payback time**

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Overall**	
<b>ROI (Net Revenue /Start-up Cost)*</b>	21.5%	8.9%	-3.6%	7.0%	15.6%	-6.3%	-0.1%	3%	
								Average	Median
<b>Payback Time to Recoup Investment</b>	4.0	8.4	NA	9.3	5.2	NA	28.4	11	8

\*Not including decreases to whole farm or home expenditures (E.G., transplant costs, heating or grocery costs)

\*\*Calculated as total net revenue for all greenhouses divided by total start-up costs for all greenhouses

## Labor inputs and returns

Each greenhouse operator was asked how much time they spent planting, watering, harvesting, and marketing crops for the foods they sold throughout the winter. Each study participant estimated their time for each month of the year and tracked one month with a daily chore log to inform their estimates.

All but one of the study participants operated the greenhouse on a part-time basis with assistance, at times, from a spouse or other family member. The greenhouse operator who spent the most time invested a total of 630 hours during the winter season, far surpassing all other operators. On average, growers spent 224 hours to produce, market, and deliver their winter crops; hours spent on growing summer transplants in the greenhouse were not included. Presented as an hourly wage, operators made between -\$5.43 to \$20.24 when calculated as operating revenue divided by total time spent working in the greenhouse (see Table 7).

**Table 7: Labor invested for winter production and time expressed as hourly wage (operating revenue/total hours worked)**

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Average	Median
<b>Total hours worked</b>	630	111.5	205	127.5	233	97	167.3	224.5	167.3
<b>Hourly wage</b>	\$7.13	\$6.17	\$1.07	\$20.24	\$17.10	\$(5.43)	\$3.48	\$7.11	\$6.17

## Other Benefits of Deep Winter Greenhouse Production

All survey participants experienced other benefits—some economic, some not—that are difficult to incorporate into a standard financial analysis such as this study, but they are no less important to many of the participants.

The ability to grow crops for family consumption emerged as a primary motivator for many greenhouse operators. One participant estimated his family consumed the equivalent of four to five bags of salad mix per week, or a value of \$400 throughout five winter months (\$20/week for 20 weeks). Other participants shared similar estimates and stories.

Likewise, all study participants shared how they used their winter greenhouse to start summer transplants. One participant estimated saving nearly \$600 in annual heating costs, because he no longer needed to use his old hoop-style greenhouse, which had been in operation more than a decade.

Other benefits, which are more intangible, include mood enhancement from enjoying a beautiful space during the middle of the winter and decreased water and space heating costs. In one instance, thermal solar panels directly heated hot water throughout the year; in others, the space heat from the greenhouse supplemented the heat of attached buildings, including a home. Some operators also used the greenhouse to dehydrate fruits, such as plum tomatoes, to produce sun-dried tomatoes during the summer months.

## WINTER GREENS GROCERY PRICE DOCUMENTATION

As winter greens, such as mustards, lettuces, kales, and arugula are the primary products grown in winter greenhouses, their pricing and availability were documented. The availability of organic greens at grocery stores during the winter was priced to inform growers of the current market mix. Organic greens were the main focus, as all study participants grew using organic methods. Seven groceries of various store formats were visited in Minnesota and Wisconsin between January and March 2015. They included the following:

- Hornbacher's (Moorhead, MN): Mainline grocery with designated organic section
- Mississippi Market (St. Paul, MN): Natural foods co-op
- The Wedge (Minneapolis MN): Natural foods co-op
- Cub Foods (Roseville, MN): Mainline grocery with designated organic section
- Seward Co-op (Minneapolis, MN): Natural foods co-op
- Coborn's (Sauk Centre, MN): Mainline grocery with designated organic section
- People's Food Co-op (LaCrosse, WI): Natural foods co-op

### National products available

According to published industry trends (Strailey, 2015), Americans currently purchase a wider variety of salad greens than they did a few years ago. Observations at the visited groceries and conversations with produce managers confirmed these trends. All groceries carried a wide variety of bagged and boxed salad greens, including baby arugula, baby kale, and a mix of Asian greens, in addition to standard bagged and boxed spring greens or salad mix.

All but one grocery carried organic greens mixes packed in either 5 oz. bags or 5 oz. clamshells marketed under the national brand names of Taylor Farms or Earthbound Farms; the remaining grocery carried similar products with almost identical pricing through its Wild Harvest private label brand. One store carried greens in 11 oz. clamshell boxes, in addition to 5 oz. portions, although bags and boxes in 5 oz. portions are standard. All but one grocery carried some portion of one or both of the Taylor Farms or Earthbound Farms organic product lines, selling from three to eight different products. The pricing was fairly consistent across all groceries:

- Taylor Farms' 5 oz. boxed greens: \$3.69 per box or \$3.49 per bag
  - Products include baby kale (100% kale), wellness blend (mix of spinach, mizuna, chard, and kale), and baby spring mix (mix of lettuces).
- Earthbound Farms' 5 oz. boxed greens: \$3.69-\$3.99 per box or \$3.29 per bag
  - Products include power greens (baby red and green chard, spinach, and kale), zen greens (baby spinach, Asian greens, and kale), spring mix, baby kale, and baby arugula.

All co-ops also carried spring mix in bulk from one of the two national brands, ranging from \$5.49 - \$6.99 per pound.

## Local products available

Only co-ops carried any local greens in their produce department at the time of the price checks. In

**Figure 1: Dragsmith Farms Mississippi Greens Micro Salad Mix in 3 oz. box**



each instance, each produce department was selling between two and four winter green products.

Two co-ops carried Dragsmith Farm micro-greens. Priced at \$7.99 for a 3 oz. box, these micro-greens are a mix of a wide variety of greens. Their micro-greens have long been available in the Twin Cities area, and a conversation with a chef at a Twin Cities farm-to-table restaurant revealed little room exists in the micro-greens market for this reason. Although deep winter greenhouses could grow and market micro-greens, all greenhouse operators in this study grow their greens to a baby size or larger.

Two other co-ops carried hydroponically-grown baby arugula and baby kale in bulk, priced at \$9.99

per pound, purchased directly from the grower. In conversation with produce managers who carried these bulk greens, neither product sold as well as the national brands, in large part due to their high price. Also, greens marketed in a box or bag make for a convenient purchase for customers.

Lastly, one co-op carried whole bibb lettuce in an individual box for \$4.29 each. The bibb lettuce was aquaponically-grown.

## Grocery market channel insights

One produce manager provided insight into co-op pricing, sharing that products at his location are priced at a 44% margin, which shoots for a final 36% margin after product loss or shrinkage—a common issue in produce departments that carry highly perishable foods. Often, he will price a local product at less than the 44% standard margin to be more price competitive and have more revenue go to the local grower. Pricing bulk greens at \$9.99 per pound, the grower received \$6 per pound and the price held at just below \$10 per pound for a 40% margin. In this case, the grower was selling directly to the co-op and not through a wholesaler, which the manager estimated would have an additional 10-20% margin on a product preceding any sales to a grocery.

Two of seven study participants sold direct to groceries with one of the two using the grocery marketing channel only to supplement income from a winter CSA when greens were plentiful. In total, the direct-to-grocery marketing channel is large, but it offers lower pricing than from direct-to-consumer marketing channels. Growers may benefit from watching their local groceries closely for which products best complement the existing marketing mix of groceries.

## **FUTURE RESEARCH**

Future financial and marketing research into deep winter greenhouse enterprises should consider the following:

- What consumers value most about winter-available products to identify the best marketing mix for winter greenhouse operators.
- Which investments in heating technology have the greatest ROI.
- The optimal space utilization in a deep winter greenhouses that maximizes production and quality.

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